FINAL REPORT
CLIMATE OF THE BEAVER RIVER RESOURCE AREA

July 31, 1981

ENVIRONMENTAL APPLICATIONS
A Division of
SCIENCE APPLICATIONS, INC.

[redacted]

FINAL REPORT
CLIMATE OF THE BEAVER RIVER RESOURCE AREA

July 31, 1981

Submitted to:

Bureau of Land Management
Salt Lake City, Utah

Submitted by:

D. Rykaczewski

July 31, 1981

ENVIRONMENTAL APPLICATIONS DIVISION
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1. INTRODUCTION

This document provides baseline data on climatology for BLM lands in the Beaver River Resource Area of the Cedar City District in Utah. Climatology considerations have become important factors in the establishment and execution of Federal land management policies. The purpose of this document is to provide information which can be used with other resource information to facilitate land use planning decisions especially in predictive vegetation modeling and fire and range management. The document is intended for use by BLM personnel in all activities involved in the management of BLM administered lands.

The data base which has been used to develop this report comprises that available in published form from governmental, academic, and private institutions within the State. These sources of data are summarized in the appropriate sections for the following climatic parameters: temperature, frost-free season, precipitation, snowfall, evaporation, solar insolation, hail and surface winds.

The report presents data which represent meaningful (i.e., long-term) and representative time periods. The analysis of the primary climatic parameters, such as temperature and precipitation are based on a minimum of 30 years of data or the period of record of the station. Nearly all of these data have been updated through 1970. Shorter periods of record were used for the secondary climatic parameters (e.g. evaporation) due to poor data availability. Caution should be used with shorter periods of record as data may not be truly representative if given years happen to be anomolous. More recent information may be obtained from the National Climatic Center in Asheville, North Carolina, or through the State Climatologist's Office at Utah State University in Logan. The State Climatologist is currently working with the BLM on expanding the climatological data bank housed at Utah State University. Programs are being written so that BLM personnel may access the USU computer and receive very current data for various climatic parameters.

Data are presented in the text in a graphics intensive manner with heavy dependence upon charts, tables, figures and overlays. The purpose of this manner of presentation is to facilitate the use of the data by BLM personnel. A key aspect of the graphical approach includes the use of topographic overlays. Figures are scaled such that they can be used in conjunction with the overlays provided in the report jacket, in order for the reader to better grasp the interactive nature of climate parameters and topography. These figures are also the same size as the BLM Areas of Responsibility and Status Map 1:1,000,000, so that this map can be used to provide further detail, as necessary.

The results of the analyses provided in this document can be used by BLM personnel for a multitude of applications. The document has been written in straightforward and simple language such that it can be used by all levels of BLM technical personnel. A sufficient review of basic principles has been provided such that it can also be used as a handbook for training purposes. This section (3.1) is not essential to the understanding of the text; however, it does provide an excellent base for making a first cut analysis for specific climatological problems. In addition, the information contained in this document is suitable for use in the development of appropriate sections of Environmental Impact Statements. Some of the data provide background information suitable for EIS sections on environmental setting. The reader is cautioned, however, that a detailed analysis of major problem areas, such as the potential impact of new pollutant sources, would require additional analytical review beyond that contained in this document.

Finally, in addition to its uses as a training handbook and for use in the preparation of Environmental Statements, this document can also be used for overall planning purposes by BLM land managers. This is one of the major intents for publishing the document. It is felt that the information contained herein will provide suitable information on which one can base judgments relative to the optimum utilization of BLM lands in terms of such potential alternatives as agriculture, forest management, range management and energy development.

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2. TOPOGRAPHY

The Beaver River R.A. is located in the Cedar City District in southwest Utah. Much of the area is a high plateau bounded by the Utah-Nevada border to the west, the Pine Valley Mountains and Zion National Park to the south, the Sevier River and Tushar Mountains to the east, and the area cuts through the Wah Wah Mountains, Wah Wah Valley and Mineral Mountains to the north. Elevations are generally on the order of 6,500 to 7,500 feet above mean sea level (MSL) in the Escalante Desert, which encompasses most of the central area of this R.A. The northern periphery contains a series of mountains and valleys including the Wah Wah Mountains, Wah Wah Valley, Frisco Mountains, Beaver River Valley, Mineral Mountains, Tushar Mountains and Sevier River Valley. Elevations in these chains generally remain under 10,000 feet MSL, with the exception of the Tushar Mountains which reach 12,173 feet MSL at Delano Peak. South of the Tushar Mountains is another area of fairly rugged terrain, just east of Cedar City. Elevations in this area are generally 10,000 to 11,000 feet MSL. Figure 2-1 provides topographic contours for the Beaver River R.A. and surrounding areas.

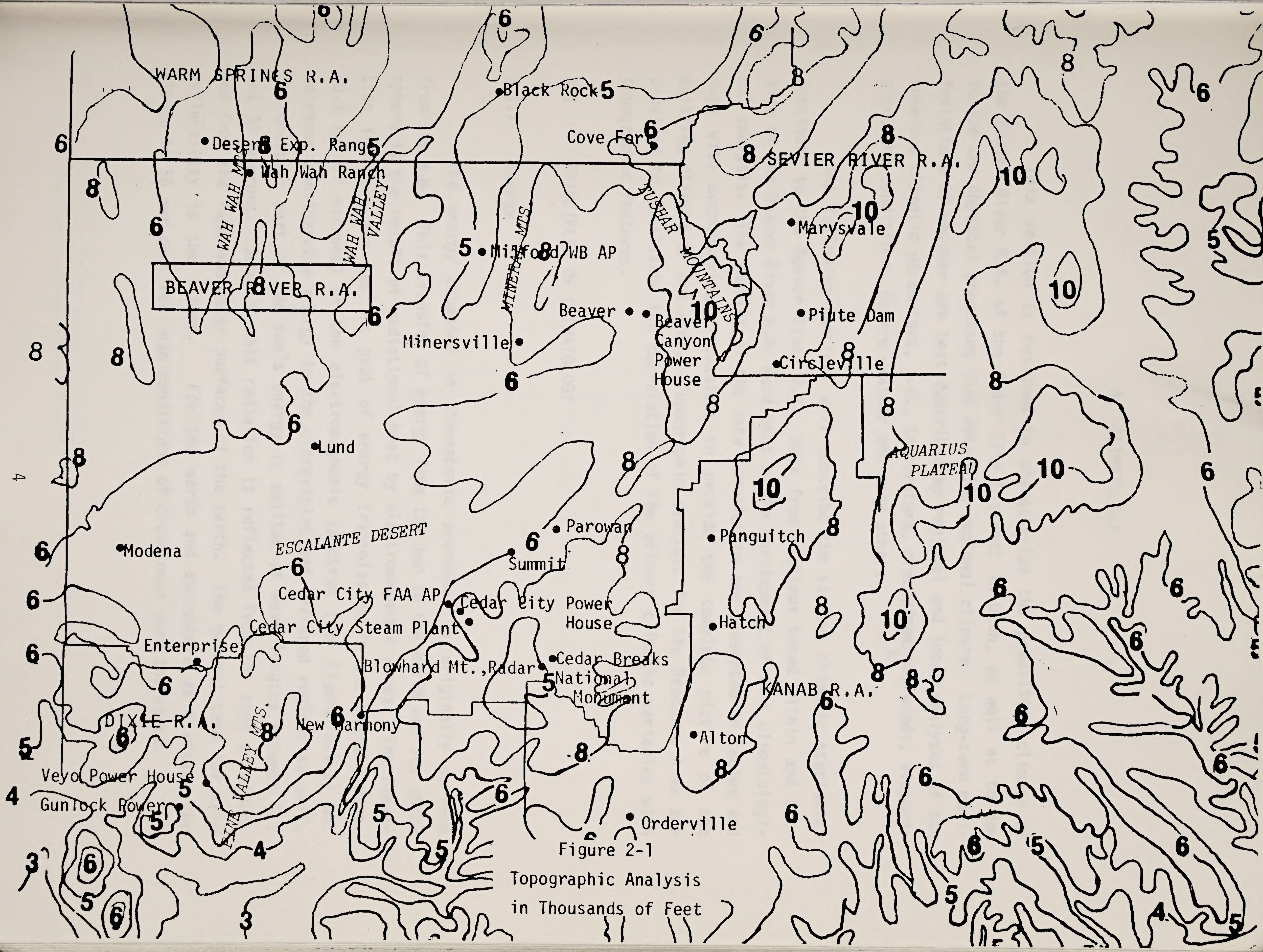

Figure 2-1
Topographic Analysis
in Thousands of Feet

3. CLIMATOLOGY

This section is designed to characterize the prevailing climate of the Beaver River R.A. of the Cedar City District in Utah, as well as to describe the physical processes that determine regional climate. Long-term manifestations of weather are best described by regional and local analyses of the numerous climatic parameters, i.e., temperature, precipitation, winds, evaporation, sky conditions, severe weather and many others.

The following sections will describe the various climatic statistics pertinent to the Beaver River R.A. Data from stations based within and outside of the Beaver River R.A. were used in the development of this climatological analysis. The results of the data compilation are presented in tables and maps with accompanying discussions to provide the complete picture of the existing climate of the area. Topographic overlays for the Resource Area are provided to facilitate the correlation of the primary climatic variables with topographic features.

3.1 PRINCIPLES OF CLIMATOLOGY

3.1.1 Energy

The energy expended in atmospheric processes is originally derived from the sun. This transfer of energy from the sun to the earth and its atmosphere is the result of radiational heat by electromagnetic waves. The radiation from the sun has its peak of energy transmission in the visible range (0.4 to 0.7 microns) of the electromagnetic spectrum (see Figure 3.1-1) but releases considerable energy in the ultraviolet and infrared regions as well. The greatest part of the sun's energy is emitted at wave lengths between 0.1 and 30 microns. Some of this radiation is reflected from the tops of clouds and from the land and water surfaces of the earth. The general term for this reflectivity is the albedo. For the earth and atmosphere as a whole, the albedo is 36 per cent for mean conditions of cloudiness over the earth.

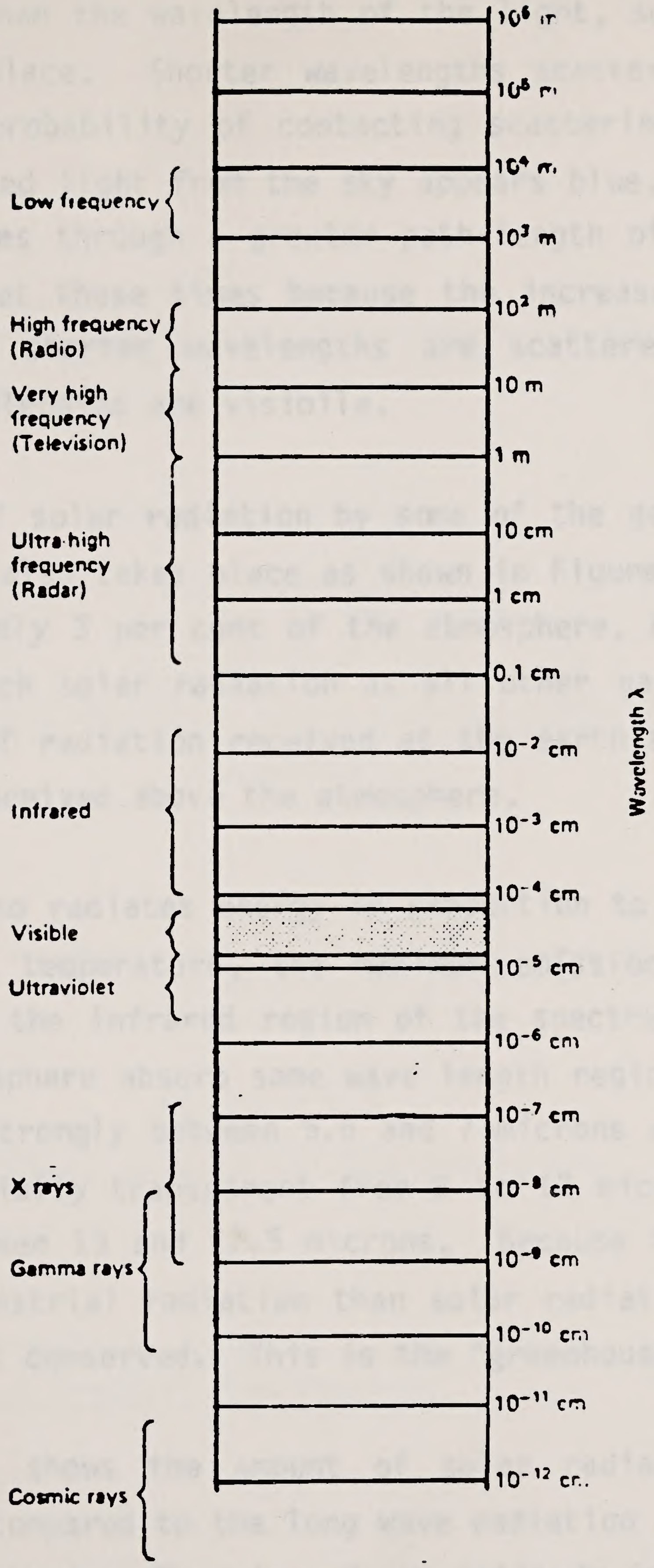

Figure 3.1-1
Electromagnetic Spectrum

Source: Seinfeld, J.H., Air Pollution: Physical & Chemical Fundamentals

This reflectivity is greatest in the visible range of wavelengths. When light (or radiation) passes through a volume containing particles whose diameter is smaller than the wavelength of the light, scattering of a portion of this light takes place. Shorter wavelengths scatter most easily because they have a greater probability of contacting scattering particles. This is the reason the scattered light from the sky appears blue. Sunlight, near sunrise and sunset, passes through a greater path-length of the atmosphere. The sky appears more red at these times because the increased path length raises the probability that shorter wavelengths are scattered early in the path length and longer wavelengths are visibile.

Absorption of solar radiation by some of the gases in the atmosphere (notably water vapor) also takes place as shown in Figure 3.1-2. Water vapor, although comprising only 3 per cent of the atmosphere, on the average absorbs about six times as much solar radiation as all other gases combined. Consequently, the amount of radiation received at the earth's surface is considerably less than that received above the atmosphere.

The earth also radiates energy in proportion to its temperature. Because of the earth's temperature, the maximum emission occurs at about 10 microns, which is in the infrared region of the spectrum (see Figure 3.1-1). The gases of the atmosphere absorb some wave length regions of this radiation. Water vapor absorbs strongly between 5.5 and 7 microns and at greater than 27 microns but is essentially transparent from 8 to 13 microns. Carbon dioxide absorbs strongly between 13 and 17.5 microns. Because the atmosphere absorbs much more of the terrestrial radiation than solar radiation, some of the heat energy of the earth is conserved. This is the "greenhouse" effect.

Figure 3.1-3 shows the amount of solar radiation absorbed by the earth and atmosphere compared to the long wave radiation leaving the atmosphere as a function of latitude. The sine of the latitude is used as the abscissa to represent area. It can be seen that if there were no transfer of heat poleward, the equatorial regions would continue to gain heat and the polar regions

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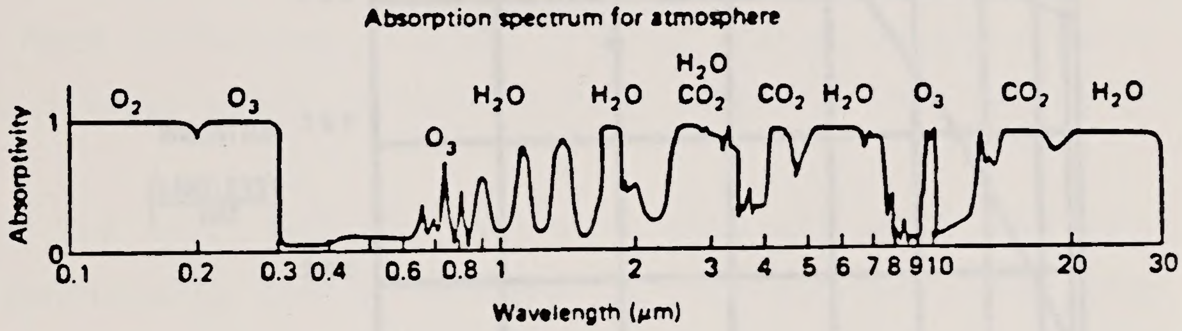
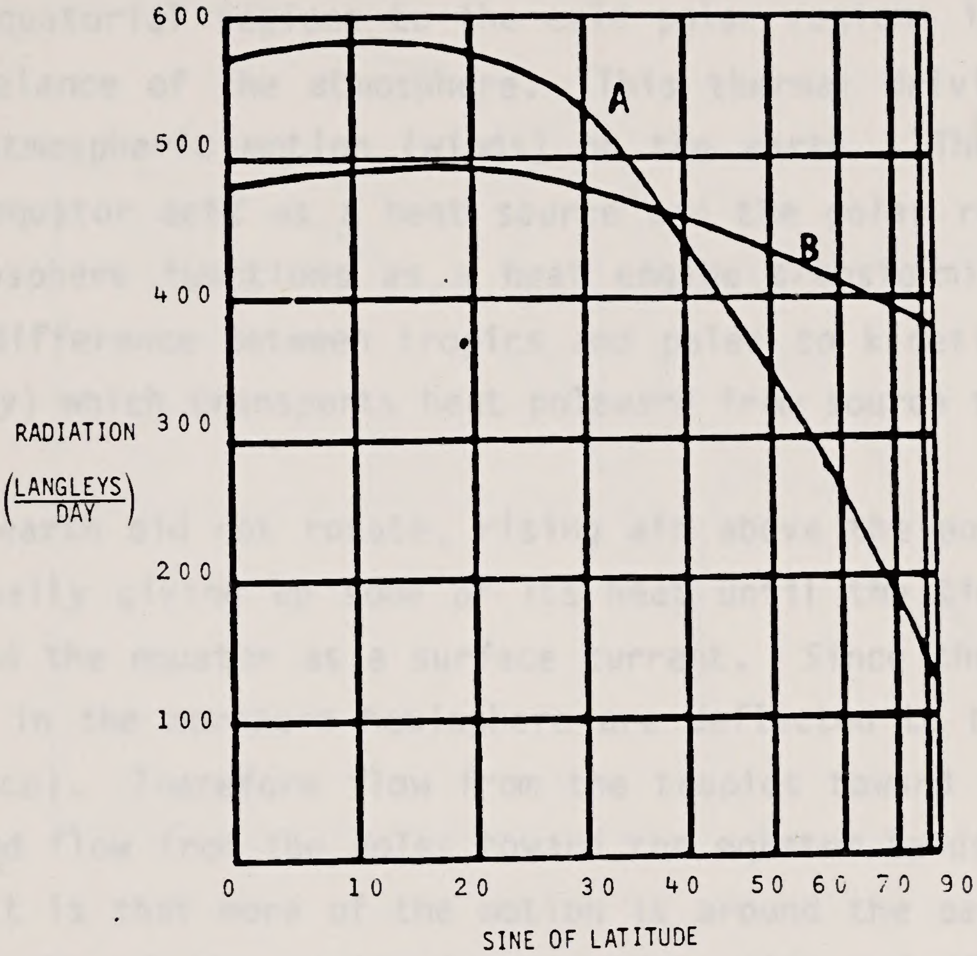


Figure 3.1-2
Absorption Spectra for the Atmosphere

Source: Miller (1966) as cited in Seinfeld, J.H., Air Pollution: Physical & Chemical Fundamentals.



A Solar Radiation Absorbed by Earth and Atmosphere

B Long Wave Radiation Leaving the Atmosphere

Figure 3.1-3
Global Radiation Balance

would continue to cool. However, annual average temperatures do remain nearly constant because of this poleward transfer of heat.

3.1.2 The General Circulation

The previous section has indicated the necessity of transfer of heat from the warm equatorial regions to the cold polar regions in order to maintain the heat balance of the atmosphere. This thermal driving force is the main cause of atmospheric motion (winds) on the earth. The portion of the earth near the equator acts as a heat source and the polar regions as a heat sink. The atmosphere functions as a heat engine transforming the potential energy of heat difference between tropics and poles to kinetic energy of motion (wind energy) which transports heat poleward from source to sink.

If the earth did not rotate, rising air above the equator would move poleward continually giving up some of its heat until the time it would sink and return toward the equator as a surface current. Since the earth does rotate, the winds in the northern hemisphere are deflected to the right (called the Coriolis force). Therefore flow from the tropics toward the poles become more westerly and flow from the poles toward the equator tends to become easterly. The result is that more of the motion is around the earth (zonal) with less than one-tenth of the motion between the poles and the equator. The meridional (along meridians, i.e., between poles and equator) circulation is broken into three cells shown in Figure 3.1-4. Utah lies in the temperate zone of the globe (between 30° and 60°N latitude); therefore, the general air circulation is from west to east. Of considerable importance is the fact that the jet stream (i.e., a core of high winds usually 50 miles per hour or more which is embedded in the westerlies in the high troposphere) does not remain long in one position but meanders north and south and is constantly changing position, moving northward in winter and southward in summer in the Northern Hemisphere. This causes changes in the location of the polar front and perturbations along the front. The migrating cyclones (counter-clockwise circulation of the wind-low pressure areas) and anticyclones (clockwise circulation

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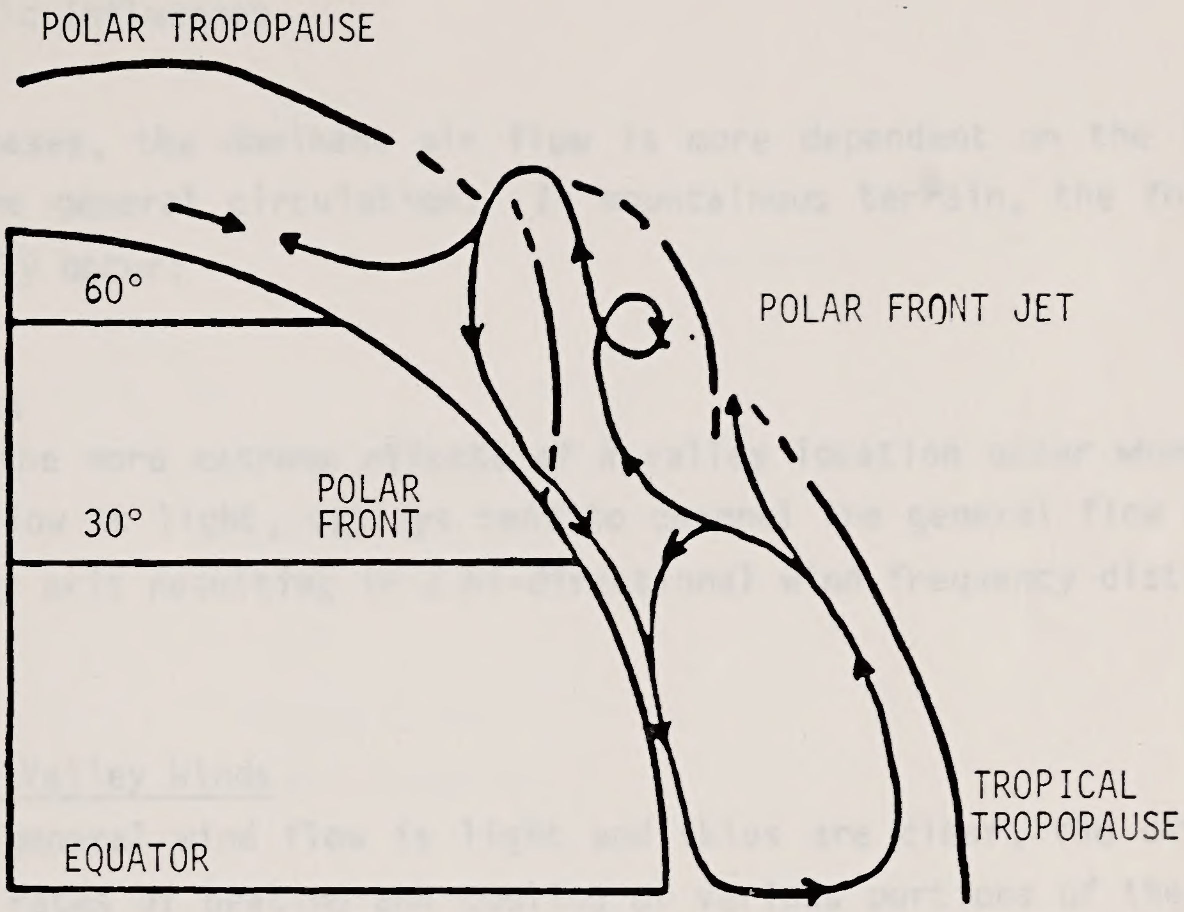

Figure 3.1-4
General Circulation Model (after Palmen)

of the wind-high pressure areas) which result, play an important part in the heat exchange, transferring heat northward both as sensible heat and also latent heat. Also, a small amount of heat is transferred poleward by the ocean currents.

3.1.3 Topographic Influences

In many cases, the dominant air flow is more dependent on the local topography than the general circulation. In mountainous terrain, the following effects commonly occur:

- <u>Channeling</u>
  Although the more extreme effects of a valley location occur when the general flow is light, valleys tend to channel the general flow along the valley axis resulting in a bi-directional wind frequency distribution.

- <u>Slope and Valley Winds</u>
  When the general wind flow is light and skies are clear, the differences in rates of heating and cooling of various portions of the valley floor and sides cause slight density and pressure differences resulting in small circulations. During the evening hours radiational heat from the Earth's surface and the resultant cooling of the ground and air adjacent to the ground causes density changes. The air at point A (Figure 3.1-5) is more dense than at point B since point A is nearer the radiating surface. Therefore, the more dense air at point A tends to flow in the general direction of B and similarly at other points along the slope. This is the slope wind.

  If the slope in Figure 3.1-5 is a side of a valley as in Figure 3.1-6, the cold air moving down the slopes will tend to drain into the valley floor and deepen with time, intensifying the radiation inversion that would form even without the addition of cold air. Any pollutants that are emitted into this air, because of the inversion structure, will have very limited vertical motion.

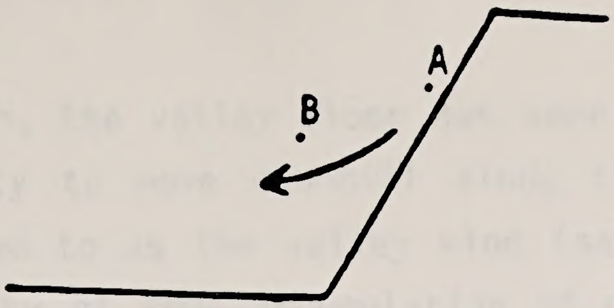

Figure 3.1-5
Slope Wind

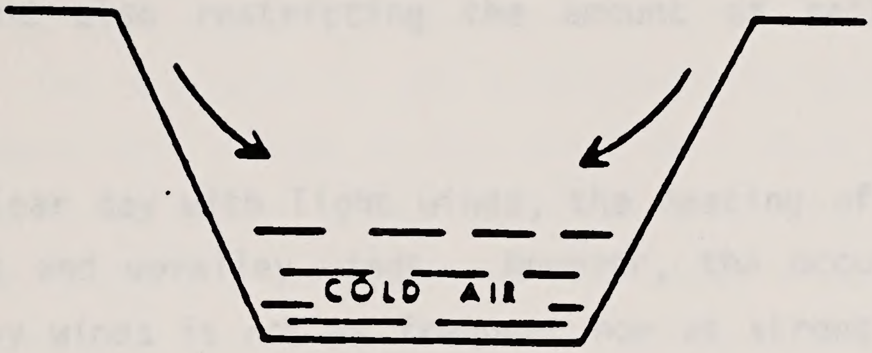

Figure 3.1-6
Valley Inversion

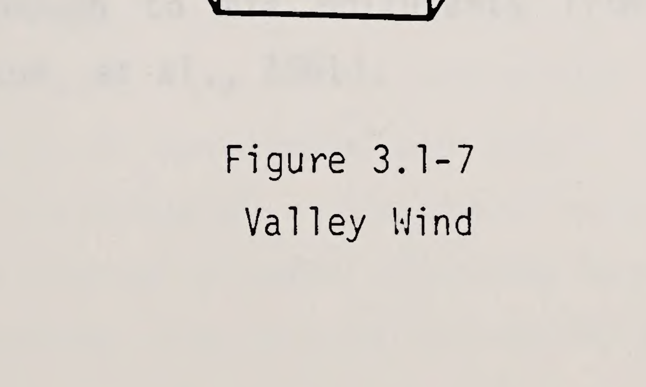

Figure 3.1-7
Valley Wind

If, in addition, the valley floor has some slope, the cold air will have a tendency to move downhill along the valley axis. This is usually referred to as the valley wind (see Figure 3.1-7). Because of the necessity of some accumulation of cold air from slope winds, the onset of the valley wind usually lags several hours behind the onset of the slope wind.

The steeper the slopes of the valley, the stronger the slope wind can become. Vegetation will tend to reduce the effect by impeding the flow and also restricting the amount of radiation that can take place.

On a clear day with light winds, the heating of the valley may cause upslope and upvalley winds. However, the occurrence of upslope and upvalley winds is not as frequent nor as strong as the downslope and downvalley winds, principally due to the fact that downslope and downvalley winds, because of their density, hug the surfaces over which they travel. Flow in complex valley systems where several valleys merge at angles or slopes varies, usually require special observations to determine flow under various meteorologic conditions.

- Inversions Aloft

The trapping of air pollutants beneath inversions aloft is also a problem encountered in valleys. Two types of inversions, warm frontal and subsidence inversions, are of particular concern since they are usually slow moving. High pollutant concentrations may occur particularly if the layer of air beneath the inversion becomes unstable enough to mix pollutants from elevated sources to ground level (Hewson, et al., 1961).

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3.1.4 Temperature

- <u>Variation with Height</u>

In the lower region of the atmosphere extending from the surface to about 2 km (6600 ft.), the temperature distribution varies considerably depending upon the character of the underlying surface and upon the amount of radiation at the surface. Within this region, the temperature may decrease with height or it may actually increase with height (inversion). This region, commonly called the lower troposphere, is the region of greatest interest in air pollution meteorology. The remainder of the troposphere is typified by a decrease of temperature with height on the order of 4 to 8°C per km. The stratosphere is a region with isothermal (constant temperature with increasing height) or slight inversion lapse rates. The layer of transition between the troposphere and stratosphere is called the tropopause. The tropopause varies in height from about 8 to 20 km (26,000 to 66,000 ft.), and is highest near the equator, lowest near the poles. Figure 3.1-8 indicates typical temperature variations with height at 60° latitude for summer and winter in the troposphere and lower stratosphere.

Above the stratosphere, the high atmosphere has several layers of differing characteristics. A rough indication of the variation of temperature with height including the high atmosphere is shown in Figure 3.1-9.

- <u>Horizontal Variation</u>

Temperature also varies horizontally particularly with latitude, being colder near the poles and warmer near the equator. However, the influence of continents and oceans have considerable effects on modifying temperatures. The continents have more extreme temperatures (continental climate) becoming warmer in summer and colder in winter, whereas the oceans maintain a more moderate temperature

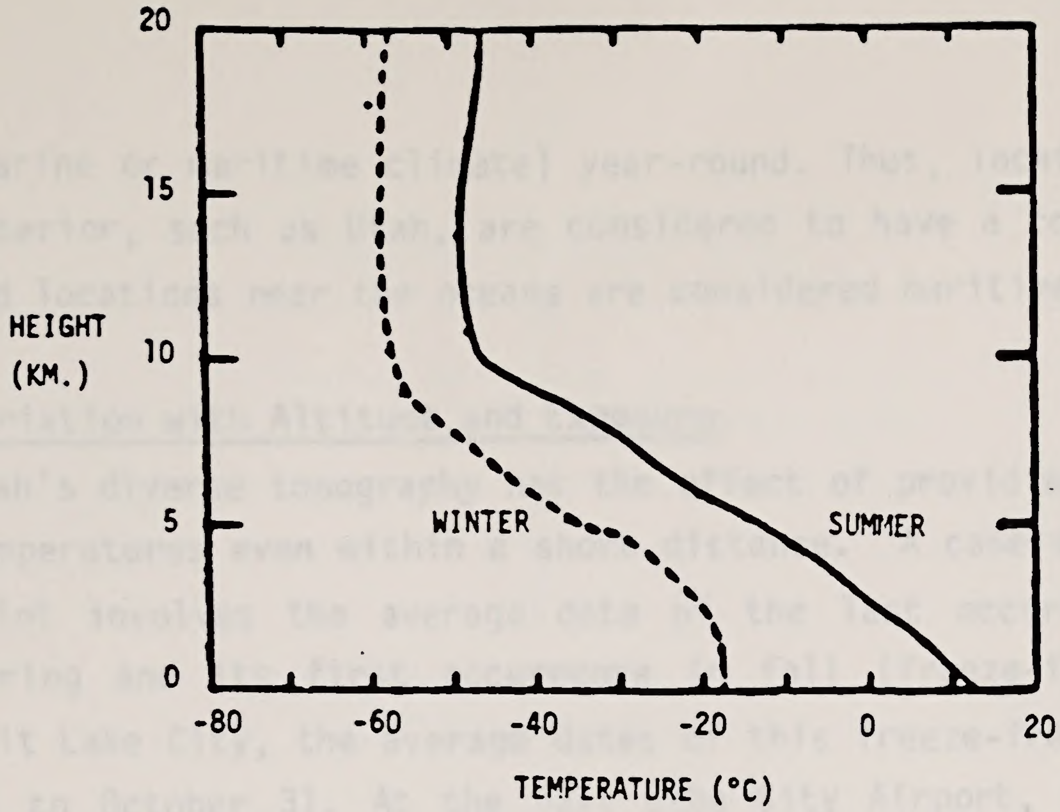

Figure 3.1-8

Variation of Temperature with Height at 60^{0} North Latitude

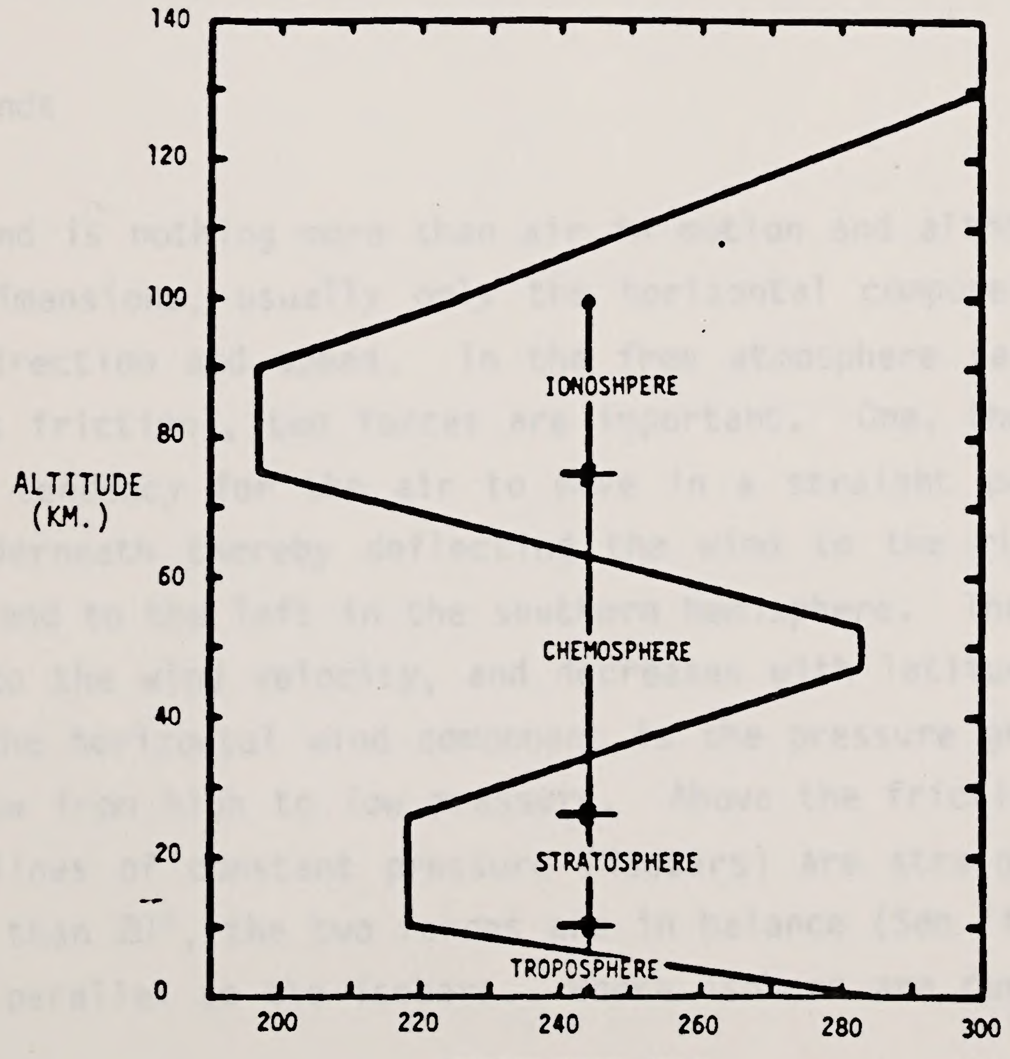

Figure 3.1-9

General Variation of Temperature with Height Throughout the Atmosphere

(marine or maritime climate) year-round. Thus, locations in the U.S. interior, such as Utah, are considered to have a continental climate and locations near the oceans are considered maritime.

- Variation with Altitude and Exposure

  Utah's diverse topography has the effect of providing a wide range of temperatures even within a short distance. A case demonstrating this point involves the average date of the last occurrence of 32°F in spring and its first occurrence in fall (freeze-free season). At Salt Lake City, the average dates of this freeze-free season is April 12 to October 31. At the Salt Lake City Airport, the average dates are April 30 and October 13. Several factors contribute to the extra 36 freeze-free days at Salt Lake. These include the fact that the Salt Lake City data were taken on top of a building being more representative of temperatures a little higher on the bench. Conversely, the airport station is located near the lowest portion of the Salt Lake Valley, and thus subjected to minimum temperatures.

3.1.5 Winds

Wind is nothing more than air in motion and although it is a motion in three dimensions, usually only the horizontal component is considered in terms of direction and speed. In the free atmosphere (above the effects of the Earth's friction), two forces are important. One, the Coriolis force, is due to the tendency for the air to move in a straight path while the Earth rotates underneath thereby deflecting the wind to the right in the northern hemisphere and to the left in the southern hemisphere. The deflection is proportional to the wind velocity, and decreases with latitude. The other force affecting the horizontal wind component is the pressure gradient force, which directs flow from high to low pressure. Above the friction layer, in regions where the lines of constant pressure (isobars) are straight and the latitude is greater than 20°, the two forces are in balance (See Figure 3.1-10) and the wind blows parallel to the isobars. Where isobars are curved, the forces are

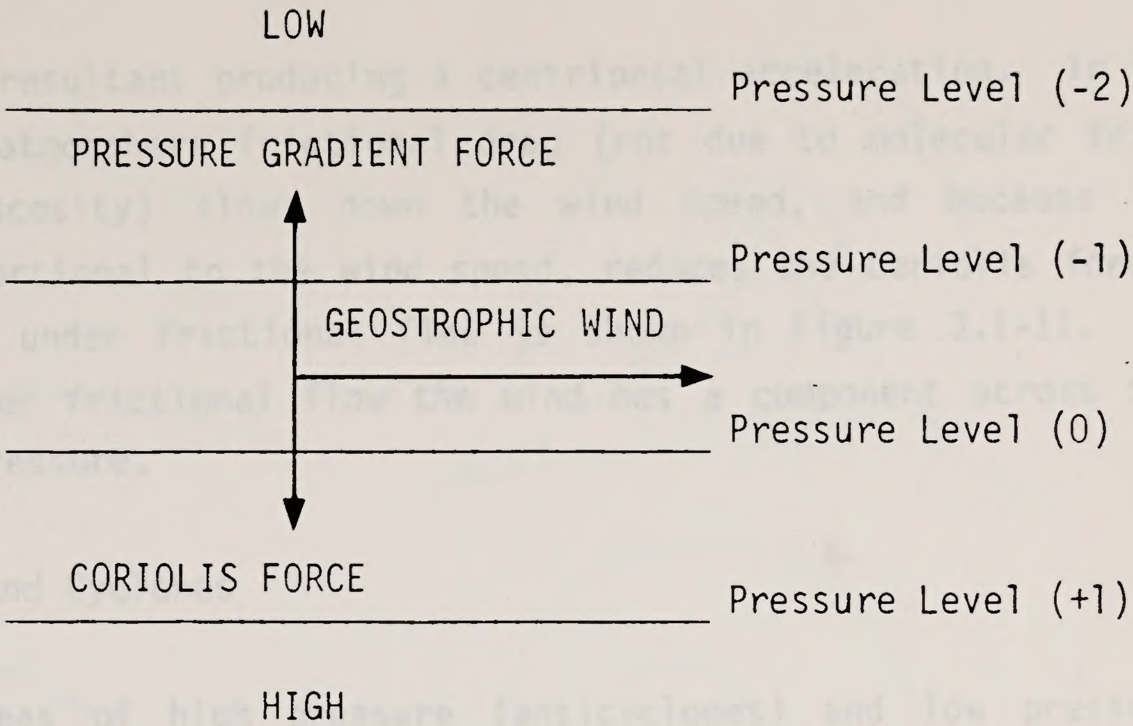

Figure 3.1-10
Balance of Forces in the Upper Atmosphere

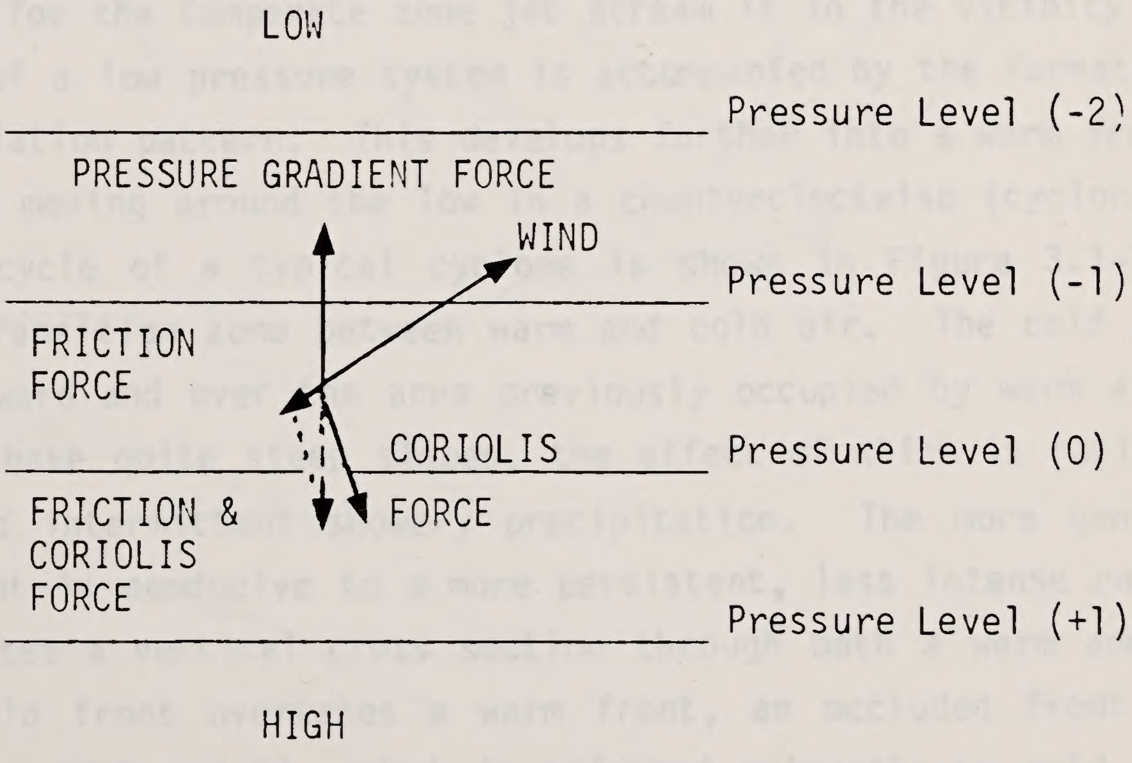

Figure 3.1-11

Balance of Forces in the Lower (Friction Layer) Atmosphere

not in balance, their resultant producing a centripetal acceleration. In the lowest portion of the atmosphere frictional drag (not due to molecular friction but to eddy viscosity) slows down the wind speed, and because the Coriolis force is proportional to the wind speed, reduces the Coriolis force. The balance of forces under frictional flow is shown in Figure 3.1-11. It will be noted that under frictional flow the wind has a component across the isobars toward lower pressure.

3.1.6 Anticyclones and Cyclones

Migrating areas of high pressure (anticyclones) and low pressure (cyclones) and the fronts associated with the latter are generally responsible for the day to day changes in weather that occur over most of the mid-latitude regions of the Earth. The low pressure systems in the atmospheric circulation are related to perturbations along the jet stream (the region of strongest horizontal temperature gradient in the upper troposphere and consequently the region of strongest winds) and form along frontal surfaces separating masses of air having different temperature and moisture characteristics. One of the favorite winter routes for the temperate zone jet stream is in the vicinity of Utah. The evolution of a low pressure system is accompanied by the formation of a wave in the circulation pattern. This develops further into a warm front and a cold front both moving around the low in a counterclockwise (cyclonic) direction. The life cycle of a typical cyclone is shown in Figure 3.1-12. The cold front is a transition zone between warm and cold air. The cold air typically is moving toward and over the area previously occupied by warm air. Cold fronts generally have quite steep slopes, the effect of which is rapidly rising warming air and intermittent showery precipitation. The more gentle slope of the warm front is conducive to a more persistent, less intense rain. Figure 3.1-13 illustrates a vertical cross section through both a warm and a cold front. As a cold front overtakes a warm front, an occluded front is formed (as in Figure 3.1-12 D and E). Utah is affected primarily by cold and occluded fronts. Stationary fronts (those which move with a speed less than 5 knots) occur only occasionally and warm fronts are quite rare over the State.

not in balance, their resultant produces a centripetal acceleration. In the lowest portion of the atmosphere frictional drag (not due to molecular friction but to eddy viscosity) slows down the wind speed, and because the Coriolis force is proportional to the wind speed, reduces the Coriolis force. The balance of forces under frictional flow is shown in figure 3.1-11. It will be noted that under frictional flow the wind has a component across the isobars toward lower pressure.

3.1.6 Anticyclones and Cyclones

Migrating areas of high pressure (anticyclones) and low pressure (cyclones) and the fronts associated with the latter are generally responsible for the day to day changes in weather that occur over most of the mid-latitude regions of the Earth. The low pressure systems in the atmospheric circulation are related to perturbations along the jet stream (the region of strongest horizontal temperature gradient in the upper troposphere and consequently the region of strongest winds) and form along frontal surfaces separating masses of air having different temperature and moisture characteristics. One of the favorite winter routes for the temperate zone jet stream is in the vicinity of Utah. The evolution of a low pressure system is accompanied by the formation of a wave in the circulation pattern. This develops further into a warm front and a cold front both moving around the low in a counterclockwise (cyclonic) direction. The life cycle of a typical cyclone is shown in figure 3.1-12. The cold front is a transition zone between warm and cold air. The cold air typically is moving toward and over the area previously occupied by warm air. Cold fronts generally have quite steep slopes, the effect of which is rapidly rising moving air and intermittent showery precipitation. The more gentle slope of the warm front is conducive to a more persistent, less intense rain. Figure 3.1-13 illustrates a vertical cross section through both a warm and a cold front. As a cold front overtakes a warm front, an occluded front is formed (as in figure 3.1-12 D and E). Utah is affected primarily by cold and occluded fronts. Stationary fronts (those which move with a speed less than 5 knots) occur only occasionally and warm fronts are quite rare over the State.

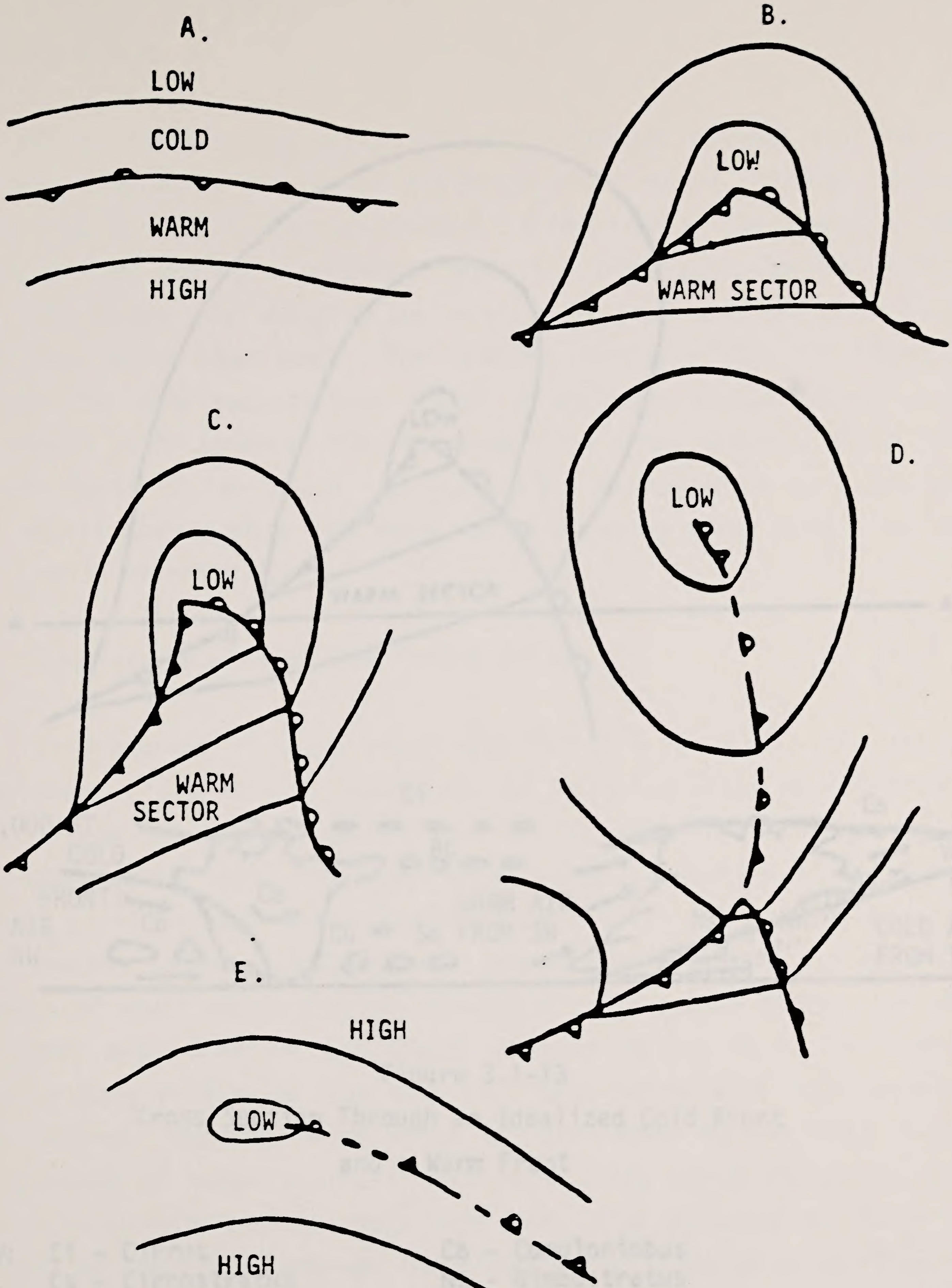

Figure 3.1-12

Idealized Development of a Low-Pressure (cyclone) System

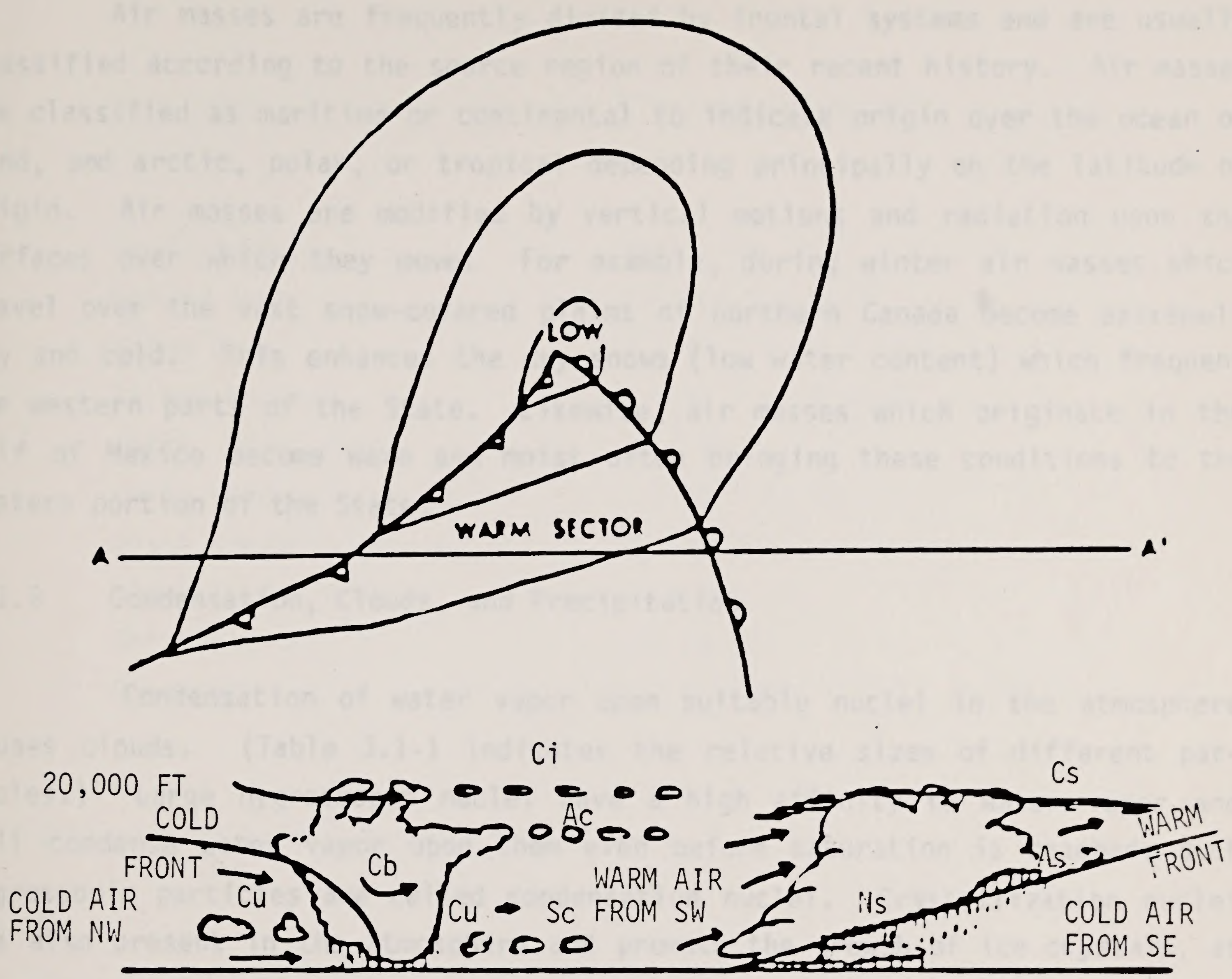

Figure 3.1-13
Cross Section Through an Idealized Cold Front
and a Warm Front

Key:

Ci - Cirrus	Cb - Cumulonimbus
Cs - Cirrostratus	Ns - Nimbostratus
Cu - Cumulus	Sc - Stratocumulus
Ac - Altocumulus	As - Altostratus

3.1.7 Air Masses

Air masses are frequently divided by frontal systems and are usually classified according to the source region of their recent history. Air masses are classified as maritime or continental to indicate origin over the ocean or land, and arctic, polar, or tropical depending principally on the latitude of origin. Air masses are modified by vertical motions and radiation upon the surfaces over which they move. For example, during winter air masses which travel over the vast snow-covered plains of northern Canada become extremely dry and cold. This enhances the dry snows (low water content) which frequent the western parts of the State. Likewise, air masses which originate in the Gulf of Mexico become warm and moist often bringing these conditions to the eastern portion of the State.

3.1.8 Condensation, Clouds, and Precipitation

Condensation of water vapor upon suitable nuclei in the atmosphere causes clouds. (Table 3.1-1 indicates the relative sizes of different particles.) Large hygroscopic nuclei have a high affinity to water vapor and will condense water vapor upon them even before saturation is reached; such hygroscopic particles are called condensation nuclei. Crystallization nuclei are also present in the atmosphere and promote the growth of ice crystals, at the expense of small water droplets within a super-cooled cloud. Of course, only a small proportion of all clouds produce rain. It is necessary that droplets increase in size so that they will have appreciable fall velocity and also to prevent complete evaporation of the drops before they reach the ground. Growth of water droplets into rain drops large enough to fall is thought to originate predominantly with the large condensation nuclei which grow larger as they fall through the cloud. The presence of an electromagnetic field in clouds generally promotes the growth of raindrops.

Table 3.1-1

Sizes of Particles

Particles	Diameter (microns)*
Small ions	less than 10^{-3}
Medium ions	10^{-3} to 5×10^{-2}
Large ions	5×10^{-2} to 2×10^{-1}
Aitken nuclei	5×10^{-2} to 2×10^{-1}
Smoke, haze, dust	10^{-1} to 2
Large condensation nuclei	2×10^{-1} to 10
Giant condensation nuclei	10 to 30
Cloud or fog droplets	1 to 100
Drizzle drops	100 to 500
Raindrops	500 to 4000

*1 Micron = 3.94×10^{-5} inches

Precipitation in Utah may be attributed to four main causes:

- Frontal activity accounts for most winter precipitation in Utah. Such storms develop in the Gulf of Alaska and move southeastward. The majority of moisture will be depleted as precipitation on the western slopes of mountains. Therefore, locations on the western slopes of the Wasatch Mountains and Wasatch Plateau receive significantly more precipitation from frontal activity than locations to the east.

- Thunderstorms are most common during the summer months. These brief, intense storms result from the influx of warm, moist air from the Gulf of Mexico. Areas east of the Wasatch Plateau are subject to a greater share of thunderstorm activity and thus, more summer precipitation than areas further west.

- Closed lows are the product of a closed counterclockwise circulation aloft. These are most common in May and October, the transition period between predominant air circulation from the Gulf of Alaska and from the Gulf of Mexico. The closed low pressure circulation produces an upward displacement of low level air and heavy precipitation often results. This accounts for a fair percentage of total precipitation in the State.

- Orographic precipitation is produced when moist air moves up a slope, cools and produces precipitation. This effect often occurs in conjunction with, and therefore increases, the precipitation from other activities. Orographic precipitation occurs throughout the year.

3.2 SOURCES OF CLIMATOLOGICAL DATA

It is necessary in the consideration of most climatological problems to obtain meteorological information. Frequently, a special observational program must be initiated to collect the required data. However, there are many situations where current or past meteorological records from a National Weather Service (NWS) station will suffice. The following outline provides a brief insight into the types of observations taken at Weather Service stations and some of the summaries compiled from these data. The discussion also serves to describe the bulk of the published data sources used in the Wyoming analysis. Many other data sources used in this report are noted in the bibliography as appropriate.

3.2.1 Observations and Records

3.2.1.1 Surface

- First Order Stations

  There are about 100 NWS stations where 24 hourly surface observations are taken daily. The data collected include: dry and wet bulb temperature (from which dew point temperature and relative humdity are calculated), pressure, wind direction and speed, cloud cover and visibility. These observations are transmitted each hour on weather teletype circuits. The data are also entered on forms which are sent to the National Climatic Center (NCC) in Asheville, North Carolina. Duplicate copies are maintained in the station files. Each station also maintains a climatological record book where certain tabulations of monthly, daily, and hourly observations are recorded. First order stations in Utah include Salt Lake City and Milford.

- <u>Military Installations</u>

  Many military installations take hourly observations. These are transmitted on military teletype circuits and not, therefore, available for general use. No routine publications of these data are prepared. The observations are sent, however, to NCC where special summaries can be produced.

- <u>Cooperative Stations</u>

  There are about 10,000 of these stations located throughout the United States. The observations, taken once each day by volunteer observers consist of maximum and minimum temperatures and 24 hour rainfall. A few cooperative stations collect additional data on evaporation and wind. However, the wind observations are taken only a few inches off the ground and are of use mainly in connection with the evaporation measurements. Observations are recorded on forms which are sent to NCC. A detailed description of Utah Cooperative Stations is provided in Table 3.2-1.

- <u>Fire Weather Service Stations</u>

  There are a number of special stations maintained during certain times of the year in forested regions where measurements of wind, relative humidity, and cloud cover are taken. These data are collected and summarized by the National Fire Weather Data Library in Fort Collins, Colorado.

3.2.1.2 Upper Air

There are nearly 70 stations in the contiguous United States where upper air observations are taken twice daily (at 0000 Greenwich Meantime (GMT) and 1200 GMT). Ogden Hill Air Force Base and Salt Lake City are the only such stations in Utah. Measurements include temperature, pressure, relative humidity and wind speed and direction at several levels. These observations are transmitted via teletype and original records are sent to NCC. Since these

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Table 3.2-1

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Station	County	Index number	Latitude N.	Longitude W.	Elevation	Distance and dir. from post office	Distance and direction from previous location	Record begins Temp. Year	Record begins Temp. Month	Record begins Precip. Year	Record begins Precip. Month	Record ends Temp. Year	Record ends Temp. Month	Record ends Precip. Year	Record ends Precip. Month	Type of change	Refer to station number	Remarks
Alpine	Utah	0061	40 27	111 47	4935	0				C								
Alta	Salt Lake	0072	40 36	111 38	8760	B		C		C								12 E Sandy
Altamont	Duchesne	0074	40 19	110 18	6100	2S	0	1953	Jun	1953	Jun							Known as Mt. Emmons (5921) prior to June 1953
Alton	Kane	0088	37 26	112 29	6980	0		C		C								
Antelope Island	Davis	0194	40 55	112 10	4225	B		1952	Sep	1952	Sep							19 NW Salt Lake City
A & R Research Lab.	Salt Lake	0302	40 42	111 55	4246	B		C		C								5 SSW Salt Lake
Bauer	Tooele	0478	40 28	112 22	4955	B		C		C		1960	Jan	1960	Jan	2		2 N Stockton
Bear River Refuge	Box Elder	0508	41 28	112 16	4206	B		C		C								13 W Brigham City
Beaver	Beaver	0519	38 17	112 38	5685	0		C		C		1957	May	1957	May	3		
Beaver	Beaver	0519	38 16	112 38	5860	0	1SSW	1957	May	1957	May							
Beaver Canyon Power H.	Beaver	0527	38 18	112 29	7275	9E				C								
Bingham Canyon	Salt Lake	0699	40 32	112 09	6170	0		C		C								
Birdseye	Utah	0716	39 52	111 32	5740	5S		1960	Jun	C								
Black Rock	Millard	0730	38 43	112 58	4650	1W		1951	Apr	1951	Apr	1953	May	1953	May	3		
Black Rock	Millard	0730	38 43	112 57	4895	0	1E	1953	May	1953								
Blanding	San Juan	0736	37 37	109 28	6036	0		C		C								
Bluff	San Juan	0788	37 17	109 33	4315	0		C		C								
Bonanza	Uintah	0602	40 01	109 11	5456	0		C		C		1960	May	1960	May	1		
Bothwell	Box Elder	0841	41 43	112 15	4332	B				C				1960	Jan	2		5 W Tremonton
Boulder	Garfield	0649	37 55	111 25	6600	0		1954	Jun	1954	Jun							
Brigham City	Box Elder	0924	41 29	112 02	4335	2S		C		C								
Bryce Canyon FAA AP	Garfield	1002	37 42	112 09	7595	B		C		C								2 N Rubys Inn
Bryce Canyon Nat. Park	Garfield	1007	37 38	112 11	7960	B		C		C		1959	Jun	1959	Jun	2		4 S Rubys Inn
Callao	Juab	1144	39 54	113 43	4339	0				C				1955	Nov	3		
Callao	Juab	1144	39 54	113 43	4330	1E	1E			1955	Nov							
Castle Dale	Emery	1214	39 13	111 01	5500	0				C				1954	Jun	3		
Castle Dale	Emery	1214	39 13	111 01	5760	1N	1N			1954	Jun			1955	May	3		
Castle Dale	Emery	1214	39 13	111 01	5660	0	0	1956	Jan	1955	May							
Cedar City FAA AP	Iron	1267	37 42	113 06	5613	2WNW		C		C								
Cedar City Power House	Iron	1272	37 41	113 05	5660	2WNW		C		C								
Cedar Point	San Juan	1308	37 43	109 05	6780	B	0	1957	Jan	1957	Jan							12 WSW Dove Creek. Known as Montezuma Creek (5795) prior to Jan. 1957
Circleville	Piute	1432	38 10	112 16	6000	0				C				1955	Jan	3		
Circleville	Piute	1432	38 10	112 16	6000	1WSW	1W			1955	Jan			1955	Mar	2		
Circleville	Piute	1432	38 10	112 16	6000	1SE	1ESE	1955	Mar	1955								
Cisco	Grand	1440	38 56	109 19	4351	0		1953	Apr	1952	Sep	1959	Nov	1959	Nov	3		
Cisco	Grand	1440	38 58	109 19	4330	1W	1W	1959	Nov	1959	Nov							
City Creek Water Plant	Salt Lake	1446	40 49	111 50	5335	B	0			1956	Mar							5 NE Salt Lake City. Known as High Line City Creek (3929) prior to Mar. 1956
Clear Creek	Carbon	1472	39 39	111 09	8300	0		C		C								

Table 3.2-1 (Continued)

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Coalville	Summit	1586	40 55	111 24	5550	0		C		C								
Corinne	Box Elder	1731	41 33	112 07	4233	0		C		C								
Cottonwood Weir	Salt Lake	1759	40 37	111 47	4961	B		C		C								6 ENE Sandy
Cove Fort	Millard	1792	38 36	112 35	5700	B		1951	Mar	C								25 N Beaver
Deer Creek Dam	Wasatch	2057	40 24	111 32	5265	B		C		C		1960	Jul	1960	Jul	3		10 SW Heber
Deer Creek Dam	Wasatch	2057	40 24	111 32	5270	B	1E	1960	Jul	1960	Jul							10 SW Heber
Delta FAA AP	Millard	2090	39 23	112 31	4789	5NE		C		C								
Deseret	Millard	2101	39 18	112 36	4541	2NE		C		C		1955	Oct	1955	Oct	3		
Deseret	Millard	2101	39 17	112 39	4540	0	2SW	1955	Oct	1955	Oct							
Desert Exp. Range	Millard	2116	38 36	113 45	5252	B		C		C								28 6E Garrison
Dinosaur National Mon.	Uintah	2172	40 26	109 18	5080	B				C				1955	Jun	2		5 NNE Jensen
Dinosaur National Mon.	Uintah	2172	40 28	109 18	5080	B	0	1955	Jun	1955	Jun	1958	Apr	1958	Apr	1		5 NNE Jensen
Duchesne	Duchesne	2253	40 10	110 25	5520	1W		C		C		1957	Mar	1957	Mar	3		
Duchesne	Duchesne	2253	40 10	110 24	5515	0	1E	1957	Mar	1957	Mar							
Dugway	Tooele	2257	40 10	113 00	4359	0		C		C		1952	Feb	1952	Feb	3		
Dugway	Tooele	2257	40 10	113 00	4359	0	1NNE	1952	Feb	1952	Feb							
East Canyon	Morgan	2294	40 51	111 35	5660	B				1952	Sep							14 6SE Morgan
East Portal	Wasatch	2319	40 10	111 11	7606	B		C		C		1955	Dec	1955	Dec	3	8378	27 8SE Heber
Echo Dam	Summit	2385	40 58	111 28	5500	B		C		C								1 SE Echo City
Elberta	Utah	2418	39 57	111 57	4690	0		C		C								
Elkhorn Ashley R. S.	Uintah	2429	40 33	109 57	6650	B				C				1958	Apr	2		6 NNW Whiterocks
Emery	Emery	2484	38 55	111 15	6260	0		C		C		1959	Apr	1959	Apr	3		
Emery	Emery	2484	38 55	111 15	6210	0	1S	1959	Apr	1959	Apr	1960	Jan	1960	Jan	3		
Emery	Emery	2484	38 55	111 15	6200	1S	0	1960	Jan	1960	Jan							
Enterprise	Washington	2558	37 34	113 43	5330	0				1954	Jun							
Ephraim Sorensens Field	Sanpete	2578	39 21	111 35	5580	1SSE		C		C								
Escalante	Garfield	2592	37 48	111 36	5760	0		C		C		1958	Apr	1958	Apr	3		
Escalante	Garfield	2592	37 48	111 38	5750	0	0	1958	Apr	1958	Apr							
Eureka	Juab	2625	39 57	112 07	6530	1SE				C				1958	Apr	3		
Eureka	Juab	2625	39 57	112 07	6460	0	1NW			1958	Apr							
Fairfield	Utah	2696	40 16	112 05	4876	B		C		C								5 SE Cedar Valley
Farmington	Davis	2721	40 59	111 54	4267	0		C		C								
Ferron	Emery	2798	39 08	111 08	5925	1S		1951	Jan	1951	Jan							
Fillmore	Millard	2828	38 58	112 20	5250	0		C		C								
Fort Duchesne	Uintah	2996	40 17	109 51	4990	0		C		C								
Fruita	Wayne	3046	38 17	111 15	5418	B		C		C								10 ESE Torrey
Garfield	Salt Lake	3097	40 43	112 12	4310	2W		1951	Jan	1951	Jan							
Garland	Box Elder	3122	41 44	112 10	4350	1E		C		C								
Garrison	Millard	3138	38 56	114 02	5275	0		1951	May	1951	May							
Geneva Steel	Utah	3182	40 17	111 44	4545	B		1953	Jan	1953	Jan	1960	Feb	1960	Feb	1		1 W Orem

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Granteville Power House	Tooele	3383	40 31	112 31	4900	6SSW				C				1956	May	1		
Green River Aviation	Emery	3418	39 00	110 09	4056	1E		C		C								
Gunlock Power House	Washington	3506	37 17	113 43	4060	3ESE				C								
Hankeville FAA AP	Wayne	3611	36 25	110 42	4456	3NNE		C		C								
Hanna	Duchesne	3624	40 26	110 48	6780	1SE		1953	Oct	1952	Jun							
Hardware Ranch	Cache	3671	41 36	111 34	5560	B		1955	Dec	1955	Dec							17 6E Logan
Hatch	Garfield	3776	37 39	112 26	7000	0				C								
Heber	Wasatch	3809	40 30	111 25	5593	0		C		C								
Hiawatha	Carbon	3896	39 29	111 01	7230	0		C		C								
High Line City Creek	Salt Lake	3929	40 49	111 50	5275	B				C				1956	Mar	3	1446	5 NE Salt Lake City
Hite	Garfield	3966	37 49	110 26	3470	B		C		C								40 SSE Hankeville
Ibapah	Tooele	4174	40 02	113 59	5280	0		C		C								
Iosepa South Ranch	Tooele	4233	40 30	112 45	4350	B		1951	Aug	1951	Aug	1958	Dec	1958	Dec	1		15 SW Granteville
Jensen	Uintah	4342	40 22	109 22	4739	2W		C		C		1956	Jun	1956	Jun	3		
Jensen	Uintah	4342	40 22	109 21	4720	1W	1ESE	1956	Jun	1956	Jun							
Kamas	Summit	4467	40 39	111 17	6495	0		C		C								
Kanab Power House	Kane	4508	37 03	112 31	5010	0		C		C								
Kanosh	Millard	4527	38 48	112 26	5018	0				C								
Koosharem	Sevier	4784	38 31	111 53	8528	1N				C				1952	Jul	2		
Koosharem	Sevier	4784	38 31	111 53	6950	1N	0	1952	Jul	1952	Jul							
Lakeside	Box Elder	4846	41 14	112 52	4216	0		1951	Sep	1951	Sep	1957	Apr	1957	Apr	1		
Laketown	Rich	4856	41 49	111 19	5988	0		C		C								
La Point	Uintah	4927	40 24	109 48	5550	0				C								
La Sal	San Juan	4946	38 19	109 15	6975	0		C		C								
La Verkin	Washington	4968	37 12	113 16	3450	0		C		C								
Levan	Juab	5085	39 33	111 52	5300	0		C		C								
Lewiston	Cache	5082	41 56	111 50	4481	2ESE		C		C								
Loa	Wayne	5148	38 24	111 39	7045	0		C		C								
Logan Utah State Univ.	Cache	5186	41 44	111 49	4775	1ENE		C		C								
Logan U. S. U. Exp. Sta.	Cache	5190	41 46	111 49	4608	3NE		C		C								
Lower American Fork Ph.	Utah	5219	40 28	111 45	5044	5NNE		C		C		1957	Jul	1957	Jul	1		
Lund	Iron	5247	38 00	113 28	5091	0		C		C								
Magna Asarco Farm	Salt Lake	5330	40 42	112 08	4310	1E		1951	Jan	1951	Jan	1957	Nov	1957	Nov	1		
Manila	Daggett	5377	40 59	109 44	8375	1W		1952	Jun	1952	Jun	1957	Nov	1957	Nov	3		
Manila	Daggett	5377	41 00	109 43	8370	1NW	1NE	1957	Nov	1957	Nov							
Manti	Sanpete	5402	39 18	111 39	5575	0		C		C		1959	Oct	1959	Oct	3		
Manti	Sanpete	5402	39 15	111 38	5585	0	0	1959	Oct	1959	Oct							
Marysvale	Piute	5477	38 27	112 14	5880	0		1954	Feb	1954	Feb							

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Mexican Hat	San Juan	5562	37 09	109 52	4250	B		C		C								20 SW Bluff
Midvale	Salt Lake	5610	40 37	111 55	4340	0		C		C		1956	Aug					
Milford WB AP	Beaver	5654	38 26	113 01	5026	2N		C		C								
Minersville	Beaver	5723	38 13	112 55	5700	0				C								
Moab	Grand	5733	38 35	109 33	4000	0		C		C		1954	Apr	1954	Apr	3		
Moab	Grand	5733	38 34	109 32	4125	2SE	2SE	1954	Apr	1954	Apr	1954	Nov	1954	Nov	3		
Moab	Grand	5733	38 35	109 33	4000	0	2NW	1954	Nov	1954	Nov	1957	Nov	1957	Nov	3		
Moab 4 NW	Grand	5733	38 36	109 38	3965	4NW	4NW	1957	Nov	1957	Nov							
Modena	Iron	5752	37 48	113 55	5460	0		C		C								
Montezuma Creek	San Juan	5795	37 43	109 05	6780	B				C				1951	May	2		12 WSW Dove Creek
Montezuma Creek	San Juan	5795	37 43	109 05	6780	B	0	1951	May	1951	May	1956	Dec	1956	Dec	3	1308	12 WSW Dove Creek
Monticello	San Juan	5605	37 52	109 21	7068	0		C		C		1952	May	1952	May	3		
Monticello	San Juan	5605	37 52	109 21	7068	1SSW	1SW	1952	May	1952	May							
Moon Lake	Duchesne	5815	40 34	110 30	8150	B		C		C								60 NW Roosevelt
Morgan	Morgan	5826	41 03	111 41	5088	0		C		C		1956	Nov	1956	Nov	3		
Morgan	Morgan	5826	41 02	111 41	5070	1SW	1S	1956	Nov	1956	Nov							
Moroni	Sanpete	5637	39 32	111 35	5525	0		C		C								
Mountain Dell Dam	Salt Lake	5892	40 45	111 43	5500	B		C		C								9 E Salt Lake City
Mt. Emmons	Duchesne	5921	40 19	110 16	6100	B		C		C		1953	May	1953	May	3	0074	2 S Altamont
Murdock Power House	Wasatch	5958	40 38	111 24	5970	B				C				1959	Aug	1		6 SE Park City
Myton	Duchesne	5969	40 12	110 04	5064	0		C		C								
Nephi	Juab	6135	39 43	111 50	5133	0		C		C								
New Harmony	Washington	6181	37 29	113 18	5290	0		1952	Jul	C								
Oak City	Millard	6357	39 23	112 20	5075	0		C		C								
Ogden Pioneer Power H.	Weber	6404	41 15	111 57	4400	2NE		C		C								
Ogden Sugar Factory	Weber	6414	41 14	112 02	4280	3W		C		C								
Orderville	Kane	6534	37 18	112 38	5460	1SW		C		C								
Ouray	Uintah	6566	40 05	109 41	4850	0		1955	Aug	1955	Aug							
Panguitch	Panguitch	6601	37 49	112 26	6670	0		C		C		1953	Aug	1953	Aug	3		
Panguitch	Panguitch	6601	37 50	112 26	6660	1NE	1NE	1953	Aug	1953	Aug	1957	May	1957	May	3		
Panguitch	Panguitch	6601	37 49	112 26	6700	0	1SSW	1957	May	1957	May	1956	Sep	1958	Sep	3		
Panguitch	Panguitch	6601	37 49	112 27	6720	1W	2NW	1956	Sep	1956	Sep							
Park Valley	Box Elder	6656	41 49	113 21	5613	0		C		C		1951	May	1951	May	3		
Park Valley	Box Elder	6656	41 49	113 20	5620	0	1E	1951	May	1951	May							P. O. also moved 1 E
Parowan	Iron	6686	37 50	112 50	6025	0		C		C		1954	Jul	1954	Jul	3		
Parowan	Iron	6686	37 51	112 50	5975	1NNW	1NNW	1954	Jul	1954	Jul							
Partoun	Jaub	6706	39 39	113 53	4750	B		C		C								4 SW Trout Creek
Payson	Utah	6724	40 03	111 44	4625	0				C								
Pineview Dam	Weber	6869	41 15	111 51	4816	B		C		C		1959	Nov	1959	Nov	3		4 W Huntsville
Pineview Dam	Weber	6869	41 15	111 50	4940	B	1ENE	1959	Nov	1959	Nov							3 W Huntsville
Piute Dam	Piute	6897	36 19	112 11	5900	B		C		C								11 SSE Marysvale

STATION INDEX AND HISTORY

Station	County	Index number	Latitude N.	Longitude W.	Elevation	Distance and dir. from post office	Distance and direction from previous location	Record begins Temp. Year	Record begins Temp. Month	Record begins Precip. Year	Record begins Precip. Month	Record ends Temp. Year	Record ends Temp. Month	Record ends Precip. Year	Record ends Precip. Month	Type of change	Refer to station number	Remarks
Pleasant Creek Power H.	Sanpete	8915	39 32	111 22	8900	B				1956	Jan							5 E Mount Pleasant
Pleasant Grove	Utah	8919	40 22	111 44	4882	0		C		C		1952	Nov	1952	Nov	3		
Pleasant Grove	Utah	8919	40 22	111 44	4668	1NE	0	1952	Nov	1952	Nov							
Price	Carbon	7015	39 38	110 48	5507	0		C		C		1957	Feb	1957	Feb	3		Equipment on roof of Courthouse Garage Sept. 1952 - Feb. 1957
Price	Carbon	7015	39 38	110 48	5560	0	0	1957	Feb	1957	Feb	1957	Sep	1957	Sep	3		
Price Game Farm	Carbon	7015	39 37	110 50	5580	3NW	3NW	1957	Sep	1957	Sep							
Provo Radio KOVO	Utah	7088	40 13	111 40	4470	28SW		1952	Apr	1952	Apr							
Richfield Radio KSVC	Sevier	7260	38 46	112 05	5308	1SE		C		C								
Richmond	Cache	7271	41 54	111 49	4650	1S		C		C								
Riverdale Power House	Weber	7318	41 09	112 00	4390	8SSW		C		C								
Roosevelt	Duchesne	7395	40 18	109 59	5104	0		C		C								
St. George Power House	Washington	7516	37 06	113 34	2700	0		C		C								
Salina	Sevier	7557	38 57	111 52	5200	1SSE		1951	Apr	C								
Salt Lake City WB AP	Salt Lake	7598	40 47	111 58	4220	4W		C		C								Roof exposure 33 feet above ground prior to July 2, 1954. Hygrothermometer commissioned Sept. 1, 1959 located 3600 feet NW of office
Santaquin Power House	Utah	7886	39 57	111 47	5220	2SSE		C		C								
Scipio	Millard	7714	39 15	112 06	5308	0		C		C								
Scofield Dam	Carbon	7724	39 47	111 07	7630	8NNE		C		C								
Silver Lake Brighton	Salt Lake	7848	40 38	111 35	8700	B		C		C								8 WSW Park City
Snake Creek Power House	Wasatch	7909	40 33	111 30	5950	B		C		C								3 NW Midway
Snowville	Box Elder	7931	41 58	112 43	4550	0		C		C		1960	Jan	1960	Jan	1		
Soldier Summit	Wasatch	7959	39 56	111 04	7454	0		C		C								
Spanish Fork 1 S	Utah	8114	40 08	111 40	4820	1S		C		C		1960	Jan	1960	Jan	2		
Spanish Fork Power House	Utah	8119	40 05	111 36	4711	4SE		C		C								
Strawberry Res. E. Portal	Wasatch	8378	40 10	111 11	7606	B	0	1958	Jan	1956	Jan							27 SSE Heber. Known as East Portal (2319) prior to Jan. 1956
Summit	Iron	8456	37 48	112 56	5946	0				1951	Nov							
Terminal	Salt Lake	8631	40 45	112 00	4230	B				C								8 W Salt Lake City
Thompsons	Grand	8705	38 58	109 43	5150	0		C		C								
Timpanogos Cave	Utah	8733	40 27	111 43	5523	B		C		C								8 N Pleasant Grove
Tooele	Tooele	8771	40 32	112 18	4820	0		C		C								
Tropic	Garfield	8847	37 37	112 06	8296	0		C		C								
Uintah	Weber	8885	41 09	111 55	4830	B				C				1960	May	1		6 SSE Ogden
University of Utah	Salt Lake	8922	40 46	111 51	4700	B		C		C								2 E Salt Lake City. Roof exposure 33 feet above ground
Utah Lake Lehi	Utah	8973	40 22	111 54	4497	B		C		C								5 W Lehi
Vernal AP	Uintah	9111	40 27	109 31	5280	1SE		C		C								
Wah Wah Ranch	Beaver	9152	38 29	113 25	4980	B		1955	Aug	1955	Aug							23 WNW Milford
Wanship Dam	Summit	9165	40 48	111 24	5950	B		1955	Aug	1955	Aug							9 S Coalville

Table 3.2-1 (Continued)

STATION INDEX AND HISTORY

UTAH

Station	County	Index number	Latitude N.	Longitude W.	Elevation	Distance and dir. from post office	Distance and direction from previous location	Record begins Temp. Year	Record begins Temp. Month	Record begins Precip. Year	Record begins Precip. Month	Record ends Temp. Year	Record ends Temp. Month	Record ends Precip. Year	Record ends Precip. Month	Type of change	Refer to station number	Remarks
Wendover FAA AP	Tooele	9382	40 44	114 02	4234	1SE		C		C		1959	Apr	1959	Apr	1		
Wendover	Tooele	9382	40 44	114 02	4300	0	1NNW			1959	May			1959	Sep	2		
Wendover WB AP	Tooele	9382	40 44	114 02	4237	1S	1S	1959	Sep	1959	Sep							
Woodruff	Rich	9595	41 32	111 09	6343	1ENE		C		C								
Woodside	Emery	9629	39 16	110 21	4640	0		1951	May	C		1954	Feb	1954	Feb	3		
Woodside Hidden Valley	Emery	9629	39 19	110 25	4900	5NW	5NW	1954	Feb	1954	Feb	1957	May	1957	May	3		
Woodside	Emery	9629	39 16	110 21	4640	0	5SE	1957	May	1957	May	1959	Apr	1959	Apr	1		
Zion National Park	Washington	9717	37 13	112 59	4048	B		C		C								3 NNE Springfield

Reference symbols used in the Station Index and History are as follows:

A Unknown.
B Name of referenced post office is different from name of station.
C Station was established prior to 1951.

The following code is used in the type of change column.

1 Station closed.
2 Change in elements reported.
3 Station moved or name changed, but no significant break in continuity of record.

Table 3.2-1 (Continued)

STATION INDEX AND HISTORY

STATIONS EQUIPPED WITH RECORDING RAIN GAGES ONLY

UTAH

Station	County	Index number	Latitude N.	Longitude W.	Elevation	Distance and dir. from post office	Distance and direction from previous location	Record begins Temp. Year	Record begins Temp. Month	Record begins Precip. Year	Record begins Precip. Month	Record ends Temp. Year	Record ends Temp. Month	Record ends Precip. Year	Record ends Precip. Month	Type of change	Refer to station number	Remarks
Antimony	Garfield	0201	38 07	112 00	6460	1NNW				C								
Enterprise AP	Iron	2561	37 41	113 40	5199	B				C				1952	Mar	3		16 E Modena
Enterprise Beryl Jct.	Iron	2561	37 43	113 39	5220	B	2NNE			1952	Mar			1959	Jun	1		12 S Beryl
Enterprise Beryl Jct.	Iron	2561	37 45	113 39	5200	B	3N			1960	Apr							10 S Beryl
Farmington Warehouse Sta.	Davis	2726	40 59	111 53	4329	0				C								
Fruitland	Duchesne	3056	40 13	110 51	6620	0				C								
Plymouth	Box Elder	6938	41 52	112 09	4450	0				C				1958	Feb	3		
Plymouth	Box Elder	6938	41 53	112 09	4460	0	0			1958	Mar							
Salt Lake City	Salt Lake	7603	40 46	111 54	4280	0				C								Roof exposure 85 feet above ground. Former WB City Office

REFERENCE NOTES

These Reference Notes apply to stations where the only equipment is a recording type rain gage.

Amounts too small to measure, traces, are not included.

- No record, or as indicated below under E.

* Amount included in a following measurement.

E Amount is wholly or partially estimated. When estimated amounts exceed one-third of the annual total, the total is carried as a dash.

▼ Includes total for previous month.

data are collected primarily to determine large scale upper atmospheric meteorological patterns, they have relatively little refinement in the lower two to three thousand feet of the atmosphere.

3.2.2 Climatological Data

There are a number of routine and special publications available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C., 20402, that are useful in climate evaluation. A number of these are listed in Price List 48, available from the Superintendent of Documents.

3.2.2.1 Routinely Prepared Data

- Daily Weather Maps - Weekly Series
  The charts in this four page, weekly publication are a continuation of the principal charts of the former Weather Bureau publication, "Daily Weather Map." The maps are copies of the operational weather maps prepared by the National Meteorological Center in Washington, D.C. Available maps include:

  The Surface Weather Map which presents station data and the analysis for 7:00 a.m. EST;

  The 500-Millibar Height Contour chart which presents the height contours and isotherms of the 500-millibar surface at 7:00 a.m. EST;

  The Highest and Lowest Temperatures chart which presents the maximum and minimum values for the 24-hour period ending at 1:00 a.m., EST; and

  The Precipitation Areas and Amounts chart which shows areas of the country where precipitation occurred during the 24 hour period ending at 1:00 a.m., EST.

- Local Climatological Data (LCD)
  This publication presents summaries of data for all first order and cooperative stations. Two LCD publications are available from the NCC:

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- <u>Local Climatological Data (LCD)</u>

  This publication presents summaries of data for all first order and cooperative stations. The LCD publications are available from the NCC.

Monthly Issue LCD - This issue gives daily information on a number of meteorological variables and provides monthly means of temperature, heating degree days, pressure and precipitation. This publication is usually available between the 10th and 15th of the following month available for Salt Lake City and Milford.

LCD with Comparative Data (annual) - This issue, published annually, presents climatological data for the current year and normals, means, and extremes for a longer period of record for these same stations. This issue is usually available between 45 and 60 days after the end of the year.

- Northern Hemisphere Data Tabulations
  This publication, issued daily, contains approximately 30 pages of surface synoptic and upper-air observations. The surface data are for one hour only (1200 GMT).

- Climatological Data - National Summary
  This publication, issued monthly, contains a narrative summary of weather conditions, climatological data for a variety of parameters, mean monthly upper-air data and solar radiation data. Also included are a number of maps of the United States showing spatial distribution of temperature, precipitation, solar radiation and winds.

- Climatological Data (by State)
  This summary, issued monthly and annually, contains temperature and precipitation data for these stations listed in Table 3.2-1.

- Selected Climatic Maps
  This publication consists of 30 U.S. maps of various meteorological parameters including: maximum and minimum temperature, heating and cooling degree days, precipitation, relative humidity, solar radiation, and surface wind roses.

3.2.2.2 Summaries

- <u>Summary of Hourly Observation</u>
  This series of publications, Climatography of the United States, No. 82-, Decennial Census of United States Climate, has been prepared for over 100 Weather Bureau stations where 24 hourly observations are recorded. One issue is prepared for each station and, where the period of record is sufficient, the ten-year period 1951 - 1960 has been prepared. For stations where ten years of data are not available, a five-year period, 1956 - 1960, has been summarized. This series supersedes the series, "Climatography of the United States" No 30-, a five-year summary published in 1956.

- <u>Climatic Summary of the United States-Supplement for 1931 - 1952.</u>
  This summary, issued by state, contains tables of monthly and annual precipitation, snowfall, and temperature for cooperative stations within the state.

- <u>Terminal Forecasting Reference Manual</u>
  This manual describes the weather conditions at NWS stations, and contains information on local topography, visibility, precipitation, special weather occurrences, and mean wind and visibility conditions. Numerous charts are included. Monthly surface wind roses and wind rose charts correlated to restricted visibility conditions are of special interest. These studies have since been discontinued.

- <u>Key to Meteorological Records Documentation</u>
  This series of publications was established to provide guidance to those making use of observed data. A recent addition to this series, No. 4.11, "Selective Guide to Published Climatic Data Sources Prepared by U.S. Weather Bureau" (1969), is extremely useful to those using climatic data.

The Series No. 1.1, "Substation History", contains information regarding the history of station locations, type and exposure of measuring instruments, location of original meteorological records, and dates of first and last observations.

3.3 TEMPERATURE

Temperature is a critical climatological parameter for land management activities. Temperature and related parameters, such as precipitation and the length of the growing season, greatly influence the suitability of land areas for utilization in agriculture, forestry and grazing.

Ambient temperatures are determined by a multitude of factors, including:

- The intensity and duration of solar radiant energy.
- The degree of depletion of this energy by reflection, scattering and absorption in the atmosphere, which is dependent upon the amount of moisture and particulate matter in the atmosphere.
- Surface albedo (reflection of incoming solar radiation).
- The physical characteristics of the surface (e.g., snow and ice reflect more energy than dry land).
- The local heat budget in terms of terrestrial and atmospheric radiation.
- Heat exchanges involved in water phase changes (i.e., condensation, evaporation, sublimation, etc.).
- Importation or advection of warm or cold air masses (e.g., influx of warm, moist tropical air in summer and cold Canadian polar air in winter).
- Transport of heat upward or downward by vertical air currents caused by natural convection and/or mechanical turbulence (e.g., thunderstorms).

In the United States, temperature is most commonly measured in degrees Fahrenheit (°F). For this reason, temperature data and analyses presented in this report are in degrees Fahrenheit. There is, however, an increasing trend towards the use of degrees Centigrade (°C). Table 3.3-1 provides a summary of temperature conversion information for aid in the usage of both systems.

Table 3.3-1

TEMPERATURE CONVERSIONS

Temperatures in this publication are given in degrees Fahrenheit (°F). The Celsius (C) temperature scale, also called Centigrade, is used in most countries of the world. A temperature conversion scale is shown on the left, note that the values coincide only at the -40 degree mark.

°F	°C	
212	100	Water Boils [1]
194	90	
176	80	
158	70	
140	60	
134	56.7	U.S. Record High [2]
122	50	
104	40	
86	30	
68	20	
50	10	
32	0	Water Freezes [1]
14	−10	
−4	−20	
−22	−30	
−40	−40	Scales Coincide
−58	−50	
−76	−60	
−94	−70	U.S. Record Low [3]
−112	−80	
−130	−90	
−148	−100	

The standard formulas to convert °F to °C and °C to °F are shown below:

$$°F = 9/5\ °C + 32$$

$$°C = 5/9\ (°F - 32)$$

Alternate, easy to remember conversion methods follow:

$$°F = 9/5\ (°C + 40) - 40$$

$$°C = 5/9\ (°F + 40) - 40$$

To use the alternate conversion formulas for converting from one scale to the other:

(a) add 40 to the value to be converted

(b) multiply that sum by the fraction:
(5/9 for °F to °C)
(9/5 for °C to °F)

(c) subtract 40 from the product

For example, to convert 68°F to °C:

(a) add 40: 68+40 = 108

(b) multiply the sum by 5/9 (°F to °C):
5/9x108 = 60

(c) subtract 40: 60-40 = 20

(d) answer: 68°F = 20°C

1. **Under Standard Sea Level Pressure**
2. **Greenland Ranch, CA - July 10, 1913**
3. **Rogers Pass, Montana - January 20, 1954**

Temperature data are available for several stations in the Beaver River R.A.; however, in order to make the analysis more complete, data from nearby representative stations in surrounding resource areas have also been used. Resource Area boundaries and the locations of the stations used in the temperature and subsequent analyses are shown in Figure 3.3-1. This figure has also been provided as an overlay which can be used in conjunction with subsequent analyses.

3.3.1 Temperature Distribution

The data presented in Table 3.3-2 provides specific temperature information for BLM lands located within and near the Beaver River R.A. However, temperature is a variable which is subject to microclimatological effects and the actual temperature at a given location will depend upon the variables as previously discussed. The data show that variability among stations within a particular region is fairly modest and that the average values provided (rounded to whole numbers) can be used with a good degree of confidence. Caution when using these values is warranted when the elevation of a location of interest varies significantly from that of a nearby station or if a particular location experiences important micro-scale effects (e.g., anomalous ground cover conditions). This table provides the monthly and annual mean, mean maximum, mean minimum and extreme values. The period of record for each of these stations is also listed in Table 3.3-2.

Annual average temperatures range from a low value of 34°F at Blowhard Mountain to a high value of 51°F at Cedar City Steam Plant. This extreme deviation is due to the great difference in elevation at these two sites. Daily range in temperature is generally 13° to 18°F from the mean in January and 12° to 20°F from the mean in June. The highest temperature recorded in the area is 106°F, recorded at Wah Wah Range. The lowest value (-34°F) was measured at both Milford and Beaver.

Temperature data are available for several stations in the Beaver River R.A.; however, in order to make the analysis more complete, data from nearby representative stations in surrounding resource areas have also been used. Resource Area boundaries and the locations of the stations used in the temperature and subsequent analyses are shown in Figure 3.3-1. This figure has also been provided as an overlay which can be used in conjunction with subsequent analyses.

3.3.1 Temperature Distribution

The data presented in Table 3.3-2 provides specific temperature information for six towns located within and near the Beaver River R.A. However, temperature is a variable which is subject to microclimatological effects and the actual temperature at a given location will depend upon the variables as previously discussed. The data show that variability among stations within a particular region is fairly modest and that the average values provided (rounded to whole numbers) can be used with a good degree of confidence. Caution when using these values is warranted when the elevation of a location of interest varies significantly from that of a nearby station or if a particular location experiences important micro-scale effects (e.g., anomalous ground cover conditions). This table provides the monthly and annual mean, mean maximum, mean minimum and extreme values. The period of record for each of these stations is also listed in Table 3.3-2.

Annual average temperatures range from a low value of 36°F at Blawn Mountain to a high value of 51°F at Cedar City Steam Plant. This extreme deviation is due to the great difference in elevation at these two sites. Daily range in temperature is generally 15° to 18°F from the mean in January and 12° to 20°F from the mean in June. The highest temperature recorded in the area is 109°F, recorded at Van Sak Range. The lowest value (-36°F) was measured at both Milford and Beaver.

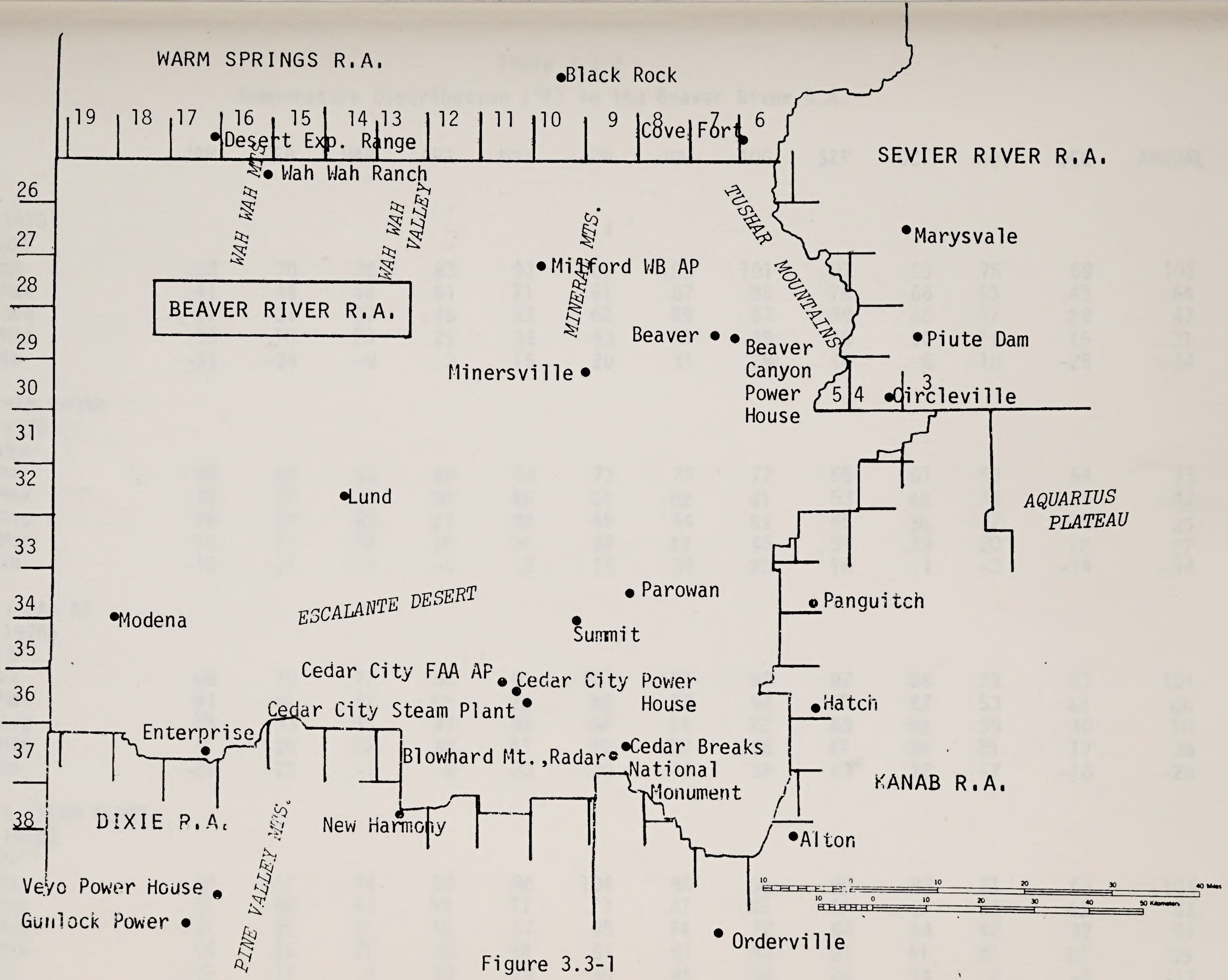

Figure 3.3-1
Stations Recording Climate Data in and Near the Beaver River R.A.

Table 3.3-2

Temperature Distribution (°F) in the Beaver River R.A.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
BEAVER (1913 - 1970) 5860'													
Ext Max	68	70	76	83	93	102	102	101	97	93	75	69	102
Mean Max	41	44	52	61	71	81	87	85	78	66	53	43	64
Mean Avg	27	31	37	45	53	62	69	67	59	48	37	29	47
Mean Min	13	18	23	29	36	43	51	49	40	30	21	15	31
Ext Min	-31	-34	-9	3	15	20	31	29	14	6	-10	-25	-34
BLOWHARD MTN RADAR (1964 - 1970) 10,690'													
Ext Max	48	49	53	58	60	73	73	72	65	61	53	54	73
Mean Max	28	28	30	35	46	54	62	61	53	46	34	25	42
Mean Avg	20	20	22	27	38	45	54	53	45	38	27	19	35
Mean Min	13	12	14	18	30	37	47	45	37	29	20	12	27
Ext Min	-10	-11	-12	-1	2	18	34	23	16	1	-3	-14	-14
CEDAR CITY FAA AP (1949 - 1970) 5613'													
Ext Max	66	70	77	82	91	101	101	99	97	86	73	67	101
Mean Max	41	46	52	62	72	82	89	87	80	67	53	44	65
Mean Avg	29	33	38	47	56	66	74	72	63	52	39	30	50
Mean Min	16	20	25	32	41	50	58	56	47	36	25	17	35
Ext Min	-26	-22	-1	8	23	30	44	36	23	12	-7	-16	-26
CEDAR CITY STEAM PLANT (1961 - 1970) 5680'													
Ext Max	64	67	74	80	86	104	96	95	90	83	71	63	104
Mean Max	42	46	50	59	71	79	87	85	77	67	53	43	63
Mean Avg	31	35	39	46	57	65	74	72	64	54	42	32	51
Mean Min	19	24	27	33	44	51	61	60	51	41	32	22	39
Ext Min	-17	-11	3	10	19	30	45	38	24	14	2	-8	-17

Table 3.3-2 (Cont'd)
Temperature Distribution

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
ENTERPRISE BERYL JCT (1961 - 1970) 5330'													
Ext Max	65	71	78	85	91	102	102	101	89	85	74	65	102
Mean Max	42	48	54	63	74	81	89	86	78	68	54	44	65
Mean Avg	27	34	38	45	55	62	70	69	59	49	38	28	48
Mean Min	11	19	21	27	36	43	51	51	40	29	21	13	30
Ext Min	-22	-23	-8	10	17	28	36	32	10	6	-2	-22	-23
LUND (1951 - 1967) 5091'													
Ext Max	66	71	78	85	94	105	105	103	104	92	77	70	105
Mean Max	42	46	55	66	75	86	93	90	83	72	54	44	67
Mean Avg	28	33	39	48	57	65	73	71	63	52	38	30	50
Mean Min	13	18	22	30	38	45	53	52	42	32	21	16	32
Ext Min	-24	-18	-5	8	19	26	37	35	23	10	-9	-24	-24
MILFORD WB AP (1911 - 1970) 5028'													
Ext Max	67	73	80	87	98	105	104	103	99	90	78	68	105
Mean Max	39	45	54	63	74	84	92	90	81	68	52	41	65
Mean Avg	26	32	39	48	57	65	74	72	62	50	37	28	49
Mean Min	13	20	25	32	39	47	56	54	43	32	22	15	33
Ext Min	-34	-27	-14	5	18	20	33	30	19	7	-13	-28	-34
MODENA (1901 - 1970) 5460'													
Ext Max	65	72	79	85	93	104	103	103	99	89	76	69	104
Mean Max	40	46	53	62	71	82	89	86	79	67	53	42	64
Mean Avg	27	32	38	46	55	64	72	70	61	50	38	29	48
Mean Min	14	20	24	30	38	46	54	53	43	33	23	16	33
Ext Min	-32	-27	-7	7	19	22	31	32	20	2	-11	-24	-32

Table 3.3-2 (Cont'd)

Temperature Distribution

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
PAROWAN (1896 - 1970) 5975'													
Ext Max	67	70	77	85	92	102	102	102	95	89	76	70	102
Mean Max	42	46	53	62	71	82	87	85	78	67	54	44	64
Mean Avg	29	33	39	47	56	65	71	70	62	51	39	31	49
Mean Min	16	20	25	32	40	48	55	54	45	35	25	18	35
Ext Min	-27	-23	-2	5	20	22	29	33	19	10	-9	-20	-27
WAH WAH RANCH (1961 - 1970) 4960'													
Ext Max	74	68	78	85	94	106	104	103	95	91	78	69	106
Mean Max	43	50	55	64	76	85	95	92	82	70	56	43	68
Mean Avg	28	35	39	47	58	66	76	74	63	52	40	29	51
Mean Min	13	21	23	30	40	48	58	56	45	34	24	16	34
Ext Min	-27	-19	-1	5	18	25	30	31	20	4	-9	-16	-27
BLACK ROCK* (1953 - 1970) 4895'													
Ext Max	67	72	81	87	94	104	105	105	98	90	79	67	105
Mean Max	43	51	56	66	76	85	93	90	83	71	54	44	67
Mean Avg	28	33	39	48	57	65	73	71	62	51	38	29	50
Mean Min	14	19	23	30	38	45	53	52	41	31	22	15	32
Ext Min	-28	-23	-27	10	19	24	36	30	22	8	-12	-22	-28
COVE FORT* (1952 - 1970) 5700'													
Ext Max	68	71	76	81	89	101	100	100	95	87	78	65	101
Mean Max	43	45	50	60	71	81	91	89	80	68	53	44	64
Mean Avg	28	30	35	44	54	62	72	70	62	50	37	30	48
Mean Min	13	16	21	28	36	43	53	52	43	31	22	15	31
Ext Min	-32	-30	-19	5	12	26	36	30	15	0	-17	-26	-32

Table 3.3-2 (Cont'd)

Temperature Distribution

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
DESERT EXP RANGE* (1950 - 1970) 5252'													
Ext Max	70	72	77	85	93	104	103	100	97	86	74	66	104
Mean Max	41	47	54	63	72	84	92	90	81	69	53	44	66
Mean Avg	27	33	38	47	56	66	74	72	63	50	37	29	50
Mean Min	12	18	23	30	39	47	55	54	44	33	21	15	33
Ext Min	-29	-19	-9	8	19	28	40	34	23	3	-10	-17	-29

*Representative of the R.A.
Source: National Climatic Center

3.3.2 Frost-Free Period

The growing season varies considerably as a function of specific crop types. Some types of vegetation continue to grow when air temperatures are near freezing (32°F), whereas other forms of plant life die at temperatures above freezing. In general, it is convenient to define the growing season by noting the mean number of days between the last occurrence in spring and first occurrence in fall of specific freezing or sub-freezing temperatures, (e.g., 32°, 28°, 24°, 20°, and 16°).

Figure 3.3-2 presents the length of the mean growing season in the Beaver River R.A. Further data is presented in Table 3.3-3. As indicated in the figure and table, the length of the growing season varies considerably throughout the area yet certain conclusions can be drawn. The length of the growing season can be closely correlated to elevation. Highest elevations generally exhibit the shortest growing season due to lower minimum temperatures at night. As elevation decreases, growing season increases and reaches a maximum value in foothill regions. Valley floors experience a somewhat shorter growing season than foothill areas. This is caused by cooling air which drains down hillsides at night and tends to collect in the lower elevations.

In the Beaver River R.A. shortest growing seasons (20 days) are seen in the higher elevations of the Tushar Mountains and near Cedar Breaks National Monument in the northeast and southeast sections of the R.A., respectively. Elevations in these areas reach 10,000 to 12,000 feet MSL. The length of the growing season increases quite significantly within a short distance as elevations decrease. In the Escalante Desert area, which encompasses the central area of the R.A, the frost-free period is generally between 80 and 140 days. In the northern mountain chains, the growing season again decreases. These areas generally have a growing season lasting 80 to 100 days.

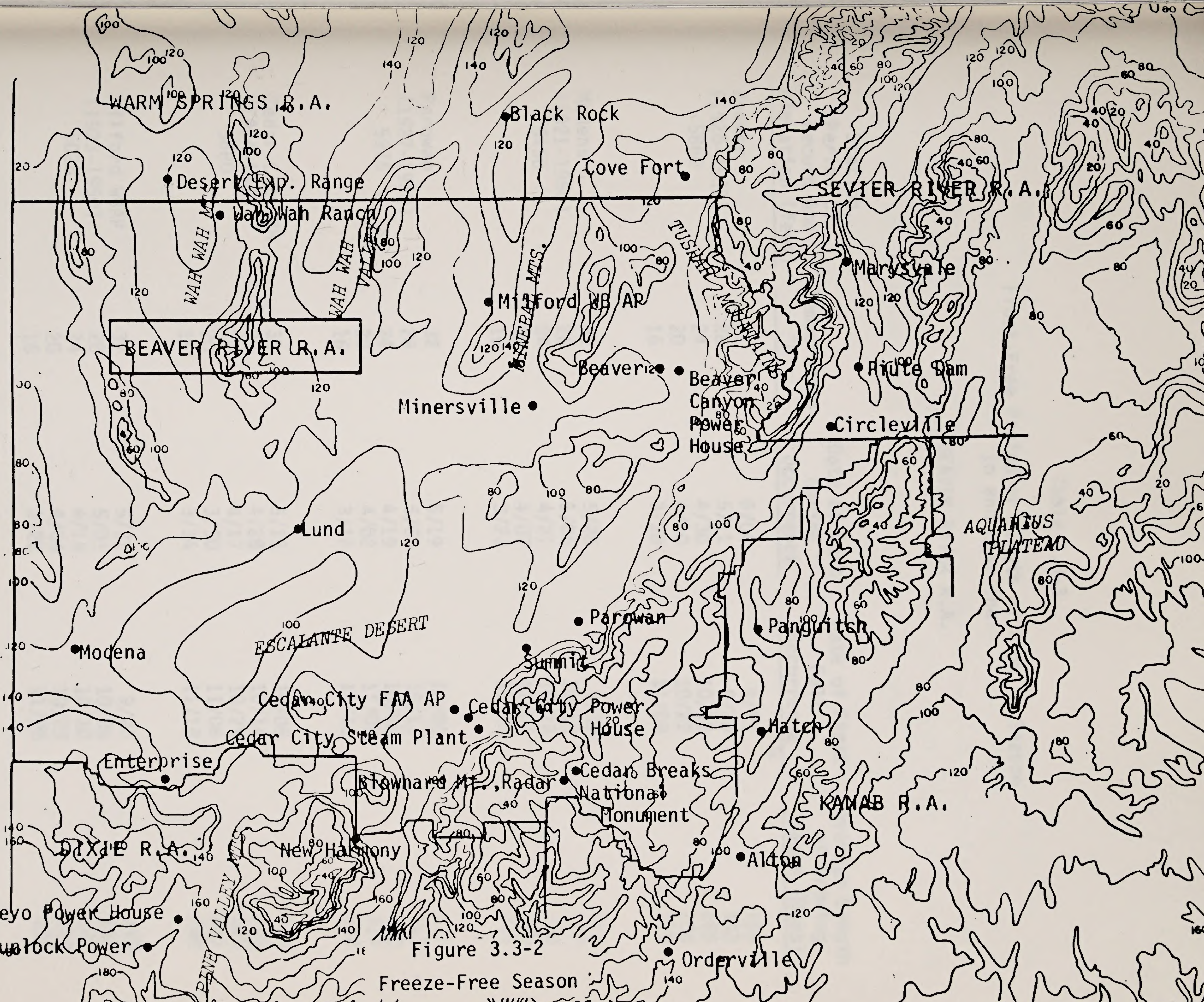

Figure 3.3-2

Freeze-Free Season

32°F freeze-free season
Values for data sparse regions were estimated based on topography and other climatic data.
Source: Hydrologic Atlas of Utah

Table 3.3-3

Frost-Free Period or Length of Growing Season
In and Near the

BEAVER RIVER R.A.

Station, Period of Record and Elevation (feet)	Temperature °F	Date of Last Spring Occurrence	Date of First Fall Occurrence	Average Length of Growing Season (Days)
Beaver	32	6/04	9/18	106
(1926-1950)	28	5/11	9/30	142
5860	24	4/30	10/12	166
	20	4/10	10/27	200
	16	3/28	11/08	225
Modena	32	5/25	9/30	128
(1921-1950)	28	5/06	10/10	157
5460	24	4/21	10/23	186
	20	4/07	11/01	208
	16	3/23	11/13	235
Parowan	32	5/19	10/03	137
(1927-1950)	28	5/03	10/13	163
5975	24	4/19	10/26	190
	20	4/02	11/05	217
	16	3/18	11/15	242
Cedar City PH	32	5/15	10/05	143
(1924-1950)	28	4/28	10/14	169
5680	24	4/17	10/29	195
	20	3/30	11/06	221
	16	3/14	11/18	248
Milford WBAP	32	5/21	9/26	128
(1923-1950)	28	5/01	10/06	158
5028	24	4/18	10/18	182
	20	4/04	10/29	208
	16	3/22	11/06	229

The length of the freeze-free period can be used to determine the mean dates of the last freeze in spring and the first freeze in fall using Table 3.3-4. These dates provided indicate the 50 percent probability level, thus during 50 percent of all years the freeze will occur prior to the date indicated and 50 percent will occur later than that date.

Table 3.3-4

Relations among the Mean Lengths of the Freeze-Free Seasons and the Mean Occurrance Dates for the Last Freeze in the Spring and the First Freeze in the Fall

Mean Length of 32° Freeze Free Season (interpolated from map)	Mean Dates of Occurrance for Freezing Temperature	
	Last 32° F in the Spring	First 32° F in the Fall
Days	Date	Date
0	July 24	July 24
10	July 19	July 29
20	July 14	Aug 3
30	July 9	Aug 8
40	July 4	Aug 13
50	June 29	Aug 18
60	June 24	Aug 23
70	June 19	Aug 28
80	June 14	Sep 2
90	June 9	Sep 7
100	June 4	Sep 12
110	May 30	Sep 17
120	May 25	Sep 22
130	May 20	Sep 27
140	May 15	Oct 2
150	May 10	Oct 7
160	May 5	Oct 12
170	Apr 30	Oct 17
180	Apr 25	Oct 22
190	Apr 20	Oct 27
200	Apr 15	Nov 1
210	Apr 10	Nov 6
220	Apr 5	Nov 11
230	Mar 31	Nov 16

Source: Hydrologic Atlas of Utah

3.4 PRECIPITATION

Precipitation plays a very important role in the effective management of large land areas for agriculture, forest management, energy development or other pertinent interests. Precipitation is one of the most basic of climatological parameters and is best described in terms of monthly, seasonal and annual means and extremes coupled with a discussion of the type of precipitation experienced in a given area. A region can be prone to either general prolonged rainfall or precipitation occurrences in short, violent bursts, such as heavy showers or thunderstorms. The nature of the precipitation is almost equal in importance to the amount of precipitation in terms of the effectiveness of the moisture for interests such as agriculture. In addition, the type of precipitation (i.e., liquid vs. frozen) and the amount of each also plays an important role.

The precipitation process is initiated with the expansion and cooling of ascending air. Therefore, it is important to investigate and understand the atmospheric conditions that cause large masses of air to spontaneously rise. Three characteristic causes that can result in precipitation are:

- Convective lifting due to unstable atmospheric conditions.
- Orographic or terrain-induced lifting of air masses.
- Large scale atmospheric disturbances.

The three are not mutually exclusive, and the precipitation process is often initiated by the joint action of several types of atmospheric lifting processes.

As the air is lifted, cooling occurs which promotes condensation. These water droplets, the result of condensation of water vapor on available nuclei, must grow in order to be of sufficient mass to fall as precipitation. Droplet growth results from several processes. The ice-crystal process is based on the principal that the saturation vapor pressure over ice is lower

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As the air is lifted, cooling occurs which promotes condensation. These water droplets, the result of condensation of water vapor on available nuclei, must grow in order to be of sufficient mass to fall as precipitation. Droplet growth results from several processes. The ice-crystal process is based on the principal that the saturation vapor pressure over ice is lower

than that over water. Therefore, in a cloud consisting of both water droplets and ice crystals, the ice elements will grow at the expense of nearby water droplets. The capture process will then be initiated. This process may also occur in clouds where ice crystals are not present. It is a process whereby gravitation attracts larger droplets which have condensed on larger nuclei. These larger droplets start to fall and coalesce or capture other droplets in their path through collisions. When droplets become sufficiently large, they will then fall to the ground as precipitation.

Precipitation in Utah may be attributed to four main causes:

- Frontal activity accounts for most winter precipitation in Utah. Such storms develop in the Gulf of Alaska and move southeastward. The majority of moisture will be depleted as precipitation on the western slopes of mountains. Therefore, locations on the western slopes of the Wasatch Mountains and Wasatch Plateau receive significantly more precipitation from frontal activity than locations to the east.

- Thunderstorms are most common during the summer months. These brief, intense storms result from the influx of warm, moist air from the Gulf of Mexico. Areas east of the Wasatch Plateau are subject to a greater share of thunderstorm activity and thus, more summer precipitation than areas further west.

- Closed lows are the product of a closed counterclockwise circulation aloft. These are most common in May and October, the transition period between predominant air circulation from the Gulf of Alaska and from the Gulf of Mexico. The closed low pressure circulation produces an upward displacement of low level air and heavy precipitation often results. This accounts for a fair percentage of total precipitation in the State.

- Orographic precipitation is produced when moist air moves up a slope, cools and produces precipitation. This effect often occurs in conjunction with, and therefore increases, the precipitation from other activities. Orographic precipitation occurs throughout the year.

The following sections provide a detailed breakdown of precipitation amounts, types and frequencies. Seasonal and annual means and extremes are provided as well as rainfall intensity, snowfall, and a detailed discussion on floods and droughts. More unusual types of precipitation, such as hail, are discussed in the section on severe weather.

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3.4.1 Monthly and Annual Distribution

Precipitation in Utah is primarily the result of the influence of maritime Pacific air and orographic influences imposed by the substantial terrain within the region. The Pacific Ocean serves as the major moisture source for precipitation in the State, especially with winter and spring low pressure systems. However, Gulf Coast moisture also contributes somewhat to the amount of moisture in Eastern Utah.

Figure 3.3-1 presents a base map which includes the selected stations for which precipitation data are available. Annual precipitation averages for each of these stations have been analyzed for the Beaver River R.A. as shown in Figure 3.4-1. This figure may be used in conjunction with the topographic overlay provided in the jacket pocket.

The figure shows that annual rainfall in the Beaver River R.A. ranges from 8 to 40 inches per year. Highest values occur in the southeast corner of the R.A., generally 25 to 40 inches. Secondary maximum areas, about 25 to 30 inches, are seen in the Tushar Mountains and Mineral Mountains of northeast Beaver River R.A. In the Escalante Desert area, precipitation averages range from 8 inches near Lund and Modena to about 12 inches on the periphery of the higher elevations. Generally, however, precipitation is about 10 inches per year in the Escalante Desert area. Table 3.4-1 details monthly means and extremes of precipitation and annual total values.

3.4.2 Precipitation During the Growing Season

Precipitation during the growing season is an important parameter to analyze for land management decision making. For example, ample rainfall is necessary to revegetate an area disturbed by mining activities. If ample rainfall is not available, other alternatives must be evaluated.

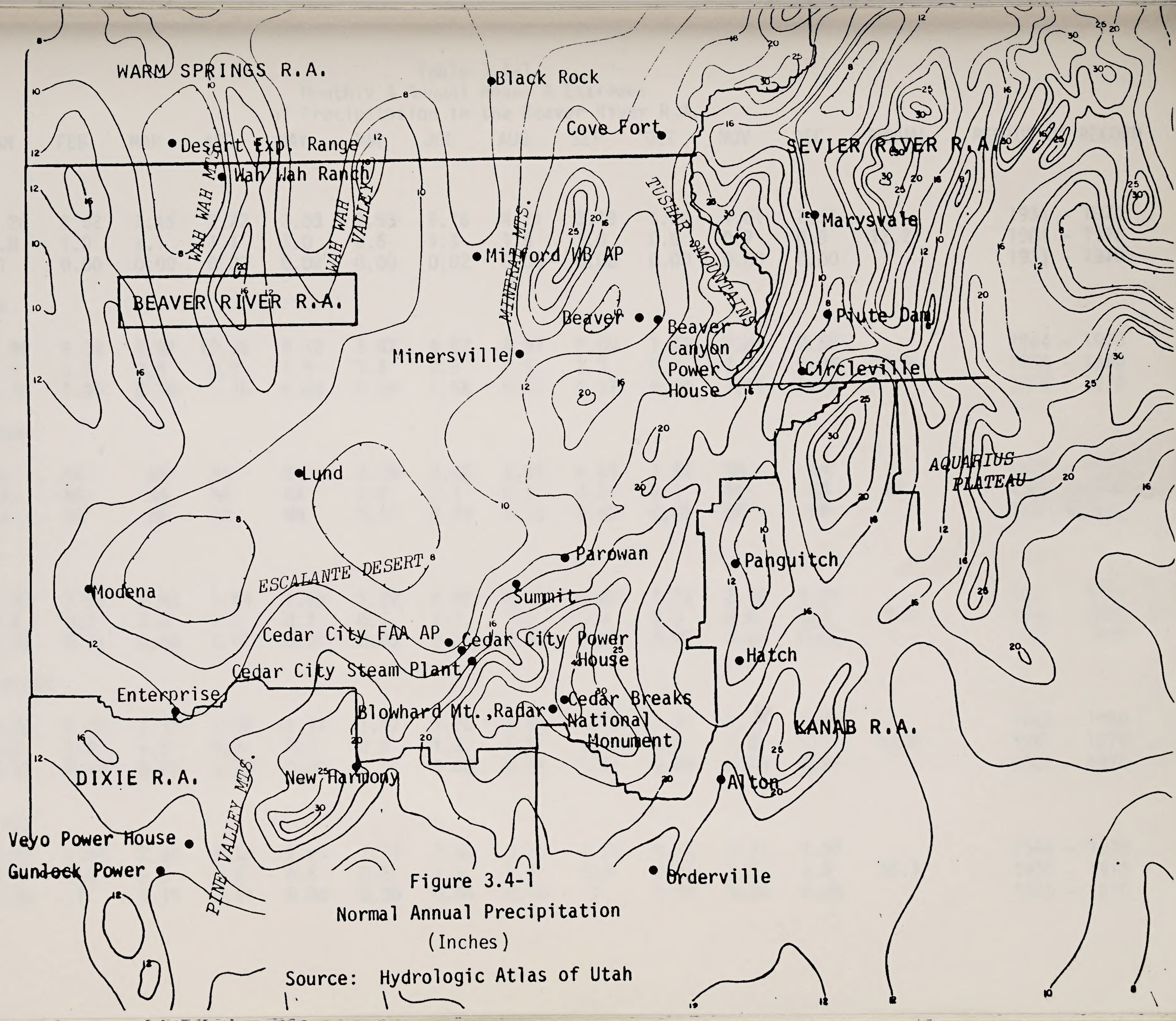

Figure 3.4-1
Normal Annual Precipitation
(Inches)

Source: Hydrologic Atlas of Utah

Table 3.4-1
Monthly & Annual Means & Extremes
of Precipitation in the Beaver River R.A.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL	PERIOD OF RECORD
BEAVER														
5860'														
Ext Max	2.26	2.52	2.45	2.72	3.03	2.53	5.76	4.21	3.49	3.20	1.61	2.51		1931 - 1970
Mean Avg	0.8	1.0	1.1	1.1	1.0	0.6	1.3	1.8	1.0	0.9	0.7	0.9	12.2	1904 - 1970
Ext Min	T	0.00	0.00	0.07	0.02	0.00	0.02	0.05	0.00	0.00	0.00	0.00		1931 - 1970
BLOWHARD MTN RADAR														
10,690'														
Ext Max	6.95	8.19	4.91	10.36	5.12	2.87	4.47	4.47	5.00	1.40	7.64	7.52		1964 - 1970
Mean Avg	3.9	3.3	3.6	5.2	1.8	1.4	2.5	2.6	1.9	0.7	3.0	3.95	33.9	1964 - 1970
Ext Min	1.78	1.09	0.70	1.78	0.24	0.89	1.68	0.57	0.67	0.00	1.43	1.48		1964 - 1970
CEDAR BREAKS NAT MON														
10,360'														
Ext Max	NA	NA	NA	NA	NA	2.05	4.42	5.63	6.65	1.77	NA	NA		1961 - 1970
Mean Avg	NA	NA	NA	NA	NA	1.2	2.5	2.9	2.7	0.7	NA	NA	NA	1961 - 1970
Ext Min	NA	NA	NA	NA	NA	0.02	0.93	0.23	0.82	0.01	NA	NA		1961 - 1970
CEDAR CITY FAA AP														
5613'														
Ext Max	1.32	2.19	2.93	1.84	1.48	1.29	2.96	4.31	4.62	1.73	2.11	1.79		1951 - 1970
Mean Avg	0.6	0.7	1.0	1.0	0.7	0.5	1.1	1.2	0.8	0.5	0.8	0.7	9.6	1948 - 1970
Ext Min	0.04	0.11	0.09	0.07	0.01	0.00	0.05	0.04	0.00	0.00	0.03	0.01		1951 - 1970
CEDAR CITY STEAM PLANT														
5980'														
Ext Max	0.90	2.73	2.11	2.16	2.07	1.47	3.56	3.45	4.96	1.24	2.70	2.52		1961 - 1970
Mean Avg	0.5	1.0	1.3	1.3	0.7	0.9	1.3	1.8	1.6	0.5	1.2	1.1	13.2	1961 - 1970
Ext Min	0.12	0.19	0.21	0.38	0.00	0.61	0.00	0.04	0.37	0.03	0.06	0.07		1961 - 1970
ENTERPRISE BERYL JCT														
5330'														
Ext Max	1.74	2.85	2.51	2.59	1.55	1.75	2.85	3.70	2.72	4.71	2.71	1.92		1940 - 1970
Mean Avg	0.9	1.0	0.9	0.8	0.6	0.5	1.1	1.1	0.8	0.6	1.2	0.8	10.3	1955 - 1970
Ext Min	0.05	T	0.15	0.11	0.00	0.00	0.04	0.00	T	0.00	0.02	0.00		1940 - 1970

Table 3.4-1 (cont'd)
Means & Extremes of Precipitation

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL	PERIOD OF RECORD
LUND 5091'														
Ext Max	1.72	1.26	2.03	1.99	1.58	1.09	1.46	3.11	1.41	2.13	2.00	2.04		1951 - 1967
Mean Avg	0.5	0.5	0.7	0.8	0.5	0.3	0.5	1.0	0.6	0.7	0.7	0.6	7.4	1950 - 1967
Ext Min	T	0.06	T	T	0.00	0.00	T	0.00	0.00	0.00	T	T		1951 - 1967
MILFORD WB AP 5028'														
Ext Max	1.63	1.50	1.83	1.80	1.58	2.43	1.42	1.69	2.60	1.82	2.10	2.45		1951 - 1970
Mean Avg	0.6	0.8	1.0	0.8	0.7	0.4	0.8	0.7	0.5	0.8	0.6	0.7	8.4	1909 - 1970
Ext Min	0.17	0.20	0.13	0.02	0.00	0.00	0.01	0.03	T	0.00	0.06	0.05		1951 - 1970
MODENA 5460'														
Ext Max	3.79	2.95	2.46	2.79	2.03	2.74	3.67	6.24	3.24	5.91	2.84	2.41		1931 - 1970
Mean Avg	0.8	0.8	1.0	0.8	0.7	0.4	1.2	1.4	0.8	0.9	0.6	0.7	10.1	1921 - 1970
Ext Min	0.03	T	T	T	0.00	0.00	0.00	T	T	0.00	0.04	0.00		1931 - 1970
PAROWAN 5975'														
Ext Max	2.54	2.59	3.79	2.48	2.68	1.90	3.00	5.04	4.10	4.02	2.59	2.61		1931 - 1970
Mean Avg	0.9	1.1	1.5	1.2	1.0	0.5	1.3	1.4	0.9	0.9	0.9	0.9	12.5	1893 - 1970
Ext Min	0.16	0.08	0.18	0.02	0.00	0.00	0.03	0.02	T	0.00	0.00	0.02		1931 - 1970
WAH WAH RANCH 4960'														
Ext Max	0.63	1.04	1.22	1.44	1.94	1.34	1.71	2.07	2.31	1.64	1.73	1.23		1956 - 1970
Mean Avg	0.3	0.4	0.6	0.7	0.6	0.4	0.6	1.1	0.7	0.5	0.5	0.3	6.7	1956 - 1970
Ext Min	0.00	T	0.03	0.00	0.00	0.01	T	0.05	0.00	0.00	0.00	0.00		1956 - 1970
BLACK ROCK * 4895'														
Ext Max	1.47	1.33	2.65	2.10	2.49	1.91	3.74	2.24	2.07	1.58	2.14	1.71		1951 - 1970
Mean Avg	0.6	0.5	1.0	1.1	0.7	0.6	0.9	0.8	0.6	0.6	0.6	0.5	8.5	1951 - 1970
Ext Min	0.00	0.04	0.08	0.09	0.05	0.00	0.00	0.07	T	0.00	0.05	0.02		1951 - 1970

Table 3.4-1 (cont'd)
Means & Extremes of Precipitaion

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL	PERIOD OF RECORD
COVE FORT *														
5700'														
Ext Max	1.92	5.25	2.30	3.97	2.61	2.68	3.42	3.59	3.73	2.46	2.76	3.26		1941 - 1970
Mean Avg	1.0	1.3	1.4	1.5	1.1	0.9	0.9	1.1	0.9	1.0	1.1	1.1	13.3	1942 - 1970
Ext Min	0.00	0.15	0.26	0.30	0.00	0.00	0.00	T	0.00	0.00	0.02	0.29		1941 - 1970
DESERT EXP RANGE *														
5252'														
Ext Max	1.16	1.09	1.22	1.73	1.53	2.05	1.89	2.41	1.94	2.10	1.69	1.24		1951 - 1970
Mean Avg	0.3	0.3	0.4	0.6	0.5	0.5	1.0	0.7	0.5	0.4	0.4	0.3	5.9	1950 - 1970
Ext Min	0.00	T	T	T	0.00	0.00	T	T	0.00	0.00	0.00	T		1951 - 1970

All Values in inches

T = Trace = < 0.01 inch

* = Representative of the R.A.

Source: National Climatic Center

Average May to September rainfall has been analyzed in Figure 3.4-2. The figure shows that about one-half of the annual precipitation falls during the May to September period in the Escalante Desert. A slightly lower percentage of the annual amount falls in the northern mountain chains and an even lower percentage in the Cedar Breaks National Monument area. In these higher elevations, snowfall accounts for a larger portion of the annual average. Table 3.4-2 provides means and extremes of precipitation for the 32°, 28° and 24° frost-free seasons as described in Section 3.3.2.

The length of the freeze-free period can be used to determine the mean dates of the last freeze in spring and the first freeze in fall using Table 3.3-4. These dates provided indicate the 50 percent probability level, thus, 50 percent of the years the freeze will occur prior to the date indicated and 50 percent will occur later than that date.

3.4.3 Rainfall Frequency and Intensity

An analysis of rainfall intensity for selected areas offers added insight into regional precipitation characteristics. Rainfall frequency and intensity studies, sometimes referred to as pluvial indices, provide an understanding of the nature of precipitation in a given region. Isopluvial maps facilitate an evaluation of rainfall intensity for particular areas over selected time periods. Isohyet analyses coupled with isopluvial studies provide an indication of the nature of the precipitation means for the area, i.e., frequent light rains versus sporadic heavy rainstorms.

Figures 3.4-3 through 3.4-14 provide isopluvial (line drawn through geographic points having the same precipitation amount likely to be equalled or exceeded during a given time period) analyses as published in the Precipitation Frequency Intensity Atlas of the Western U.S.-Volume VI, Utah. These figures provide information for the following return periods, rainfall duration times and May to October probability levels:

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An analysis of rainfall intensity for selected areas offers added insight into regional precipitation characteristics. Rainfall frequency and intensity studies, sometimes referred to as pluvial indices, provide an understanding of the nature of precipitation in a given region. Isopluvial maps facilitate an evaluation of rainfall intensity for particular areas over selected time periods. Isohyet analyses coupled with isopluvial studies provide an indication of the nature of the precipitation regime for the area, i.e., frequent light rains versus sporadic heavy rainstorms.

Figures 3.4-3 through 3.4-28 provide isopluvial (line drawn through geographic points having the same precipitation amount likely to be equalled or exceeded during a given time period) analyses as published in the Precipitation Frequency Intensity Atlas of the Western U.S.-Volume VI, Utah. These figures provide information for the following return periods, rainfall duration times and May to October probability levels:

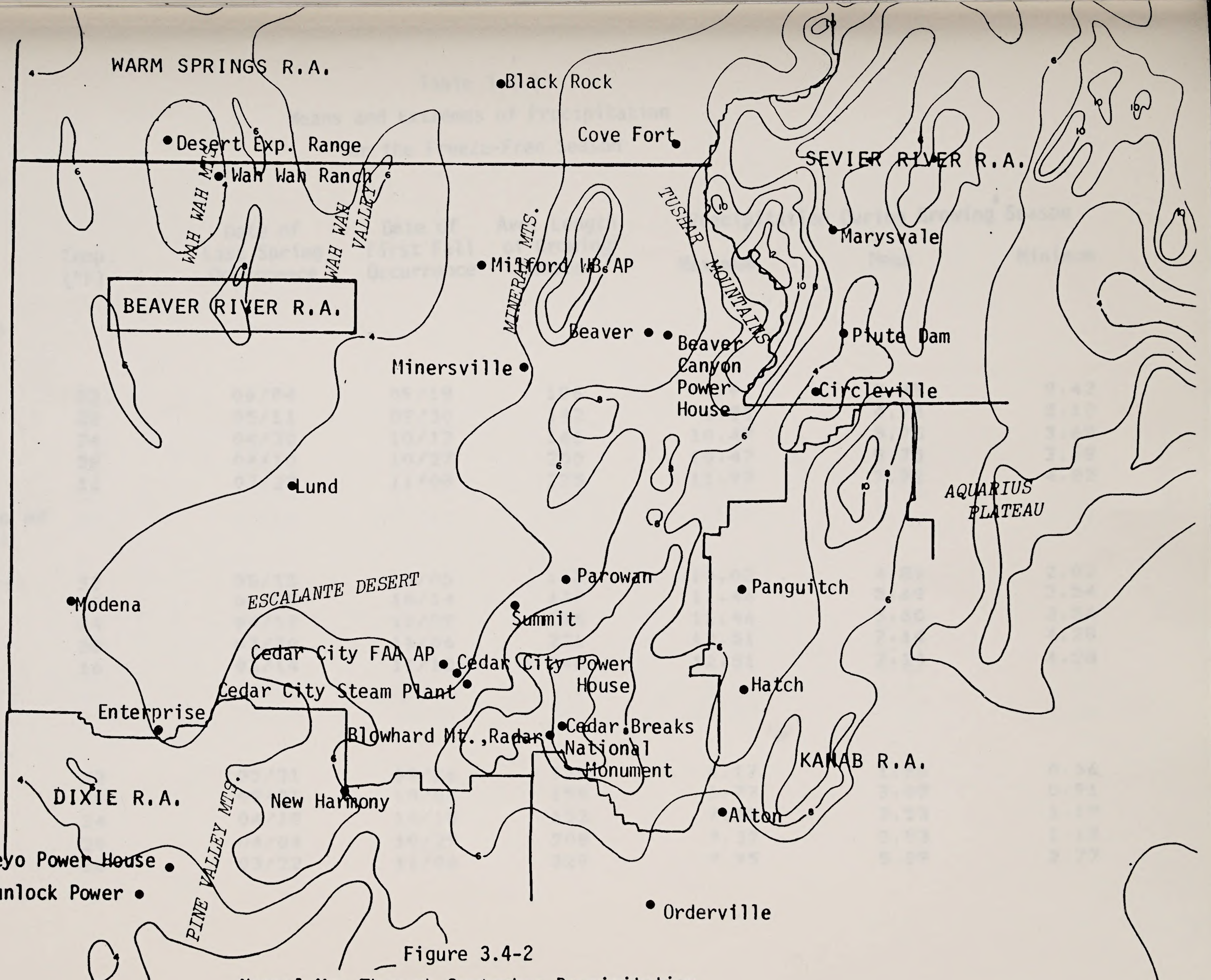

Figure 3.4-2

Normal May Through September Precipitation
(Inches)

Source: Hydrologic Atlas of Utah

Table 3.4-2

Means and Extremes of Precipitation

for the Freeze-Free Season

	Temp. (°F)	Date of Last Spring Occurrence	Date of First Fall Occurrence	Ave. Length of Growing Season	Precipitation During Growing Season		
					Maximum	Mean	Minimum
BEAVER (1926 - 1950) 5860'							
	32	06/04	09/18	106	4:94	2:48	0:42
	28	05/11	09/30	142	8:83	4:74	2:10
	24	04/30	10/12	166	10:47	5:75	3:68
	20	04/10	10/27	200	10:47	5:75	3:68
	16	03/28	11/08	225	11:97	7:31	4:82
CEDAR CITY FAA AP (1924 - 1950) 5613'							
	32	05/15	10/05	143	10.02	4.89	2.02
	28	04/28	10/14	169	11.46	5.60	2.54
	24	04/17	10/29	195	11.46	5.60	2.54
	20	03/30	11/06	221	12.51	7.14	4.28
	16	03/14	11/18	248	12.51	7.14	4.28
MILFORD WB AP (1923 - 1950) 5028'							
	32	05/21	09/26	128	4:17	1:96	0:66
	28	05/01	10/06	158	6:77	3:09	0:91
	24	04/18	10/18	182	7:32	3:53	1:19
	20	04/04	10/29	208	7:32	3:53	1:19
	16	03/22	11/06	229	7:95	5:09	2:77

Table 3.4-2

Means and Extremes of Precipitation

for the Freeze-Free Season

	Temp. (°F)	Date of Last Spring Occurrence	Date of First Fall Occurrence	Ave. Length of Growing Season	Precipitation During Growing Season Maximum	Mean	Minimum
MODENA (1921 - 1950) 5460'							
	32	05/25	09/30	128	6:94	4:21	1:70
	28	05/06	10/10	157	6:94	4:21	1:70
	24	04/21	10/23	186	7:95	4:65	1:70
	20	04/07	11/01	208	9:25	5:16	2:71
	16	03/23	11/17	235	9:85	5:97	2:81
PAROWAN (1927 - 1950) 5975'							
	32	05/19	10/03	137	7:32	4:75	2:30
	28	05/03	10/13	163	7:32	4:75	2:30
	24	04/19	10/26	190	8:48	5:41	3:46
	20	04/02	11/05	217	8:62	5:84	3:81
	16	03/18	11/15	242	10:83	7:29	5:34

- 2 year-6 hour precipitation
- 10 year-6 hour precipitation
- 25 year-6 hour precipitation
- 50 year-6 hour precipitation
- 2 year-24 hour precipitation
- 10 year-24 hour precipitation
- 25 year-24 hour precipitation
- 50 year-24 hour precipitation
- 50 percent probability-6 hour precipitation
- 20 percent probability-6 hour precipitation
- 50 percent probability-24-hour precipitation
- 20 percent probability-24-hour precipitation

Figures 3.4-3 through 3.4-10 present precipitation amounts which may occur during designated time periods based on recurrence intervals of 2, 10, 25, or 50 years. For example, Figure 3.4-3 provides isopluvials of expected precipitation amounts for a 6-hour period, that would be experienced at least once in a 2-year time frame. The isoline intervals provided on these maps were designed to provide a reasonably complete description of isopluvial patterns in various regions of the State. These analyses include all types of precipitation, i.e., rain, snow, hail, etc. Dashed intermediate lines are placed between the normal isopluvial intervals where a linear interpolation would lead to erroneous results. Cross-hatched areas show local minima.

Figures 3.4-11 through 3.4-14 delineate precipitation values for May through October and thus are applicable to the growing season. These analyses do not delineate precipitation type, but approximate the values that would be obtained by using a data series made up of precipitation events that are exclusively rain. Since data for only part of the year are used, these maps have been labeled with appropriate probabilities rather than with a return period in years. Thus, Figure 3.4-11 indicates the amount of rainfall expected to occur at the various locations during the May to October period with a 50 percent probability.

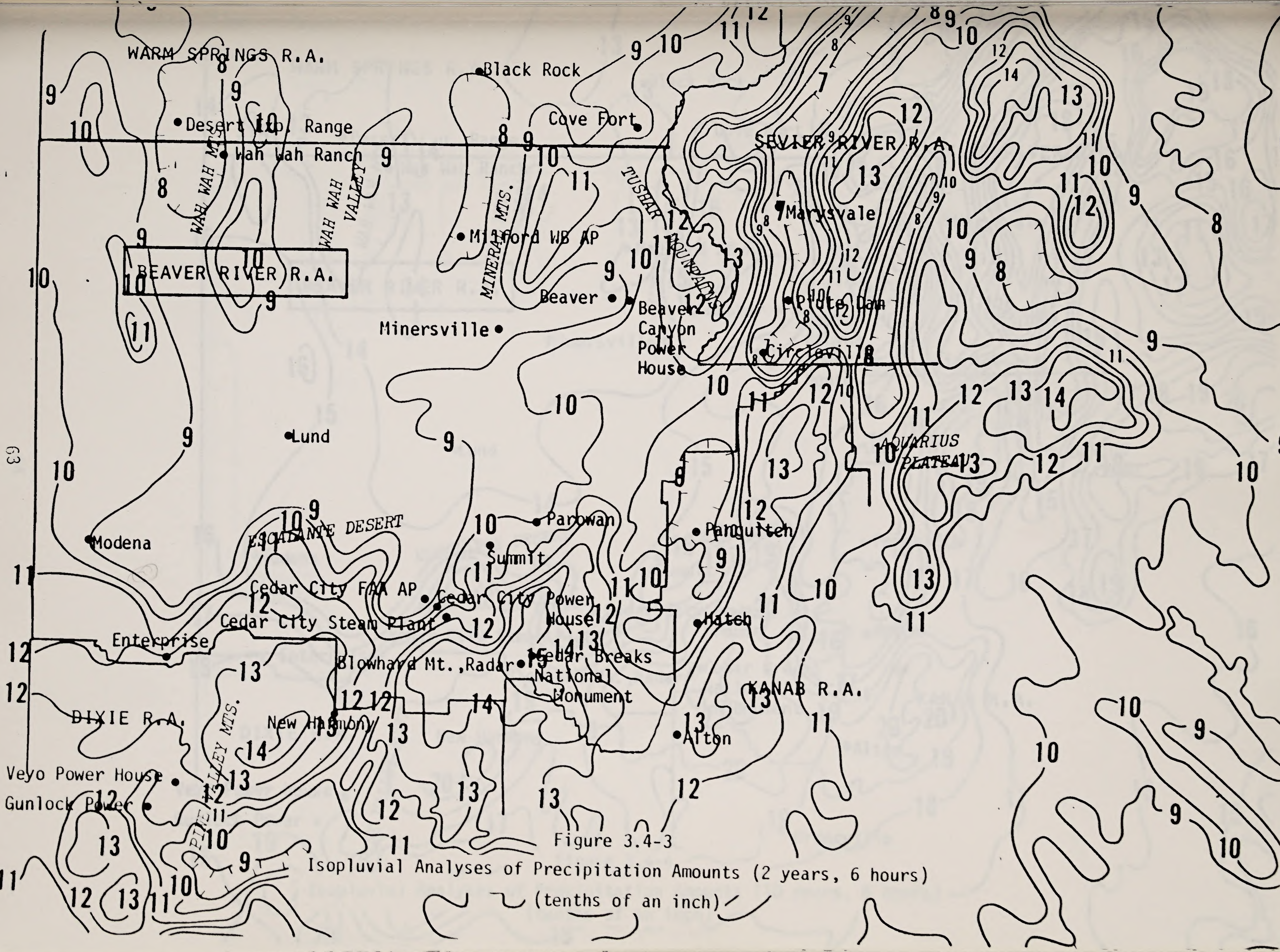

Figure 3.4-3
Isopluvial Analyses of Precipitation Amounts (2 years, 6 hours)
(tenths of an inch)

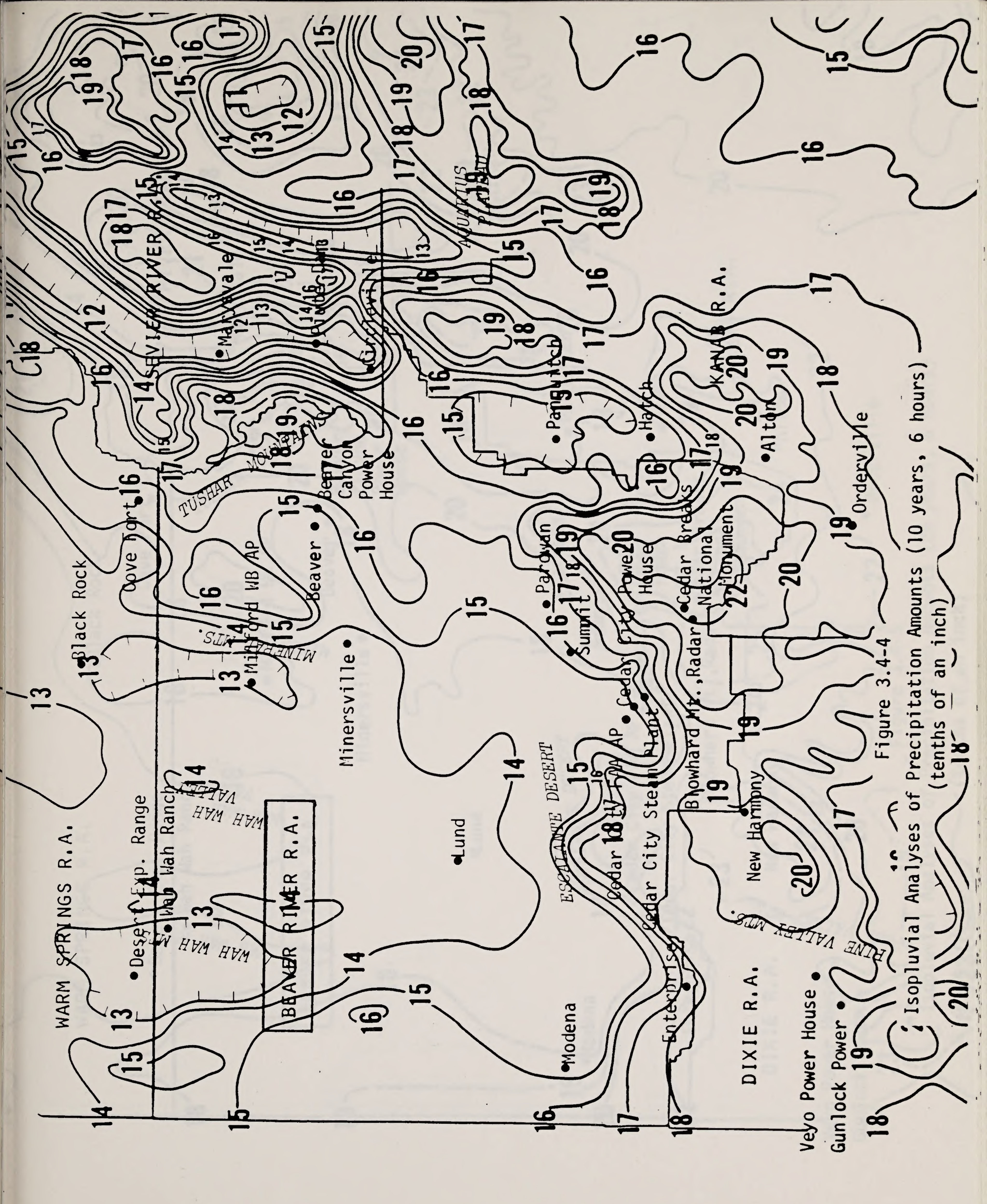

Figure 3.4-4

Isopluvial Analyses of Precipitation Amounts (10 years, 6 hours)
(tenths of an inch)

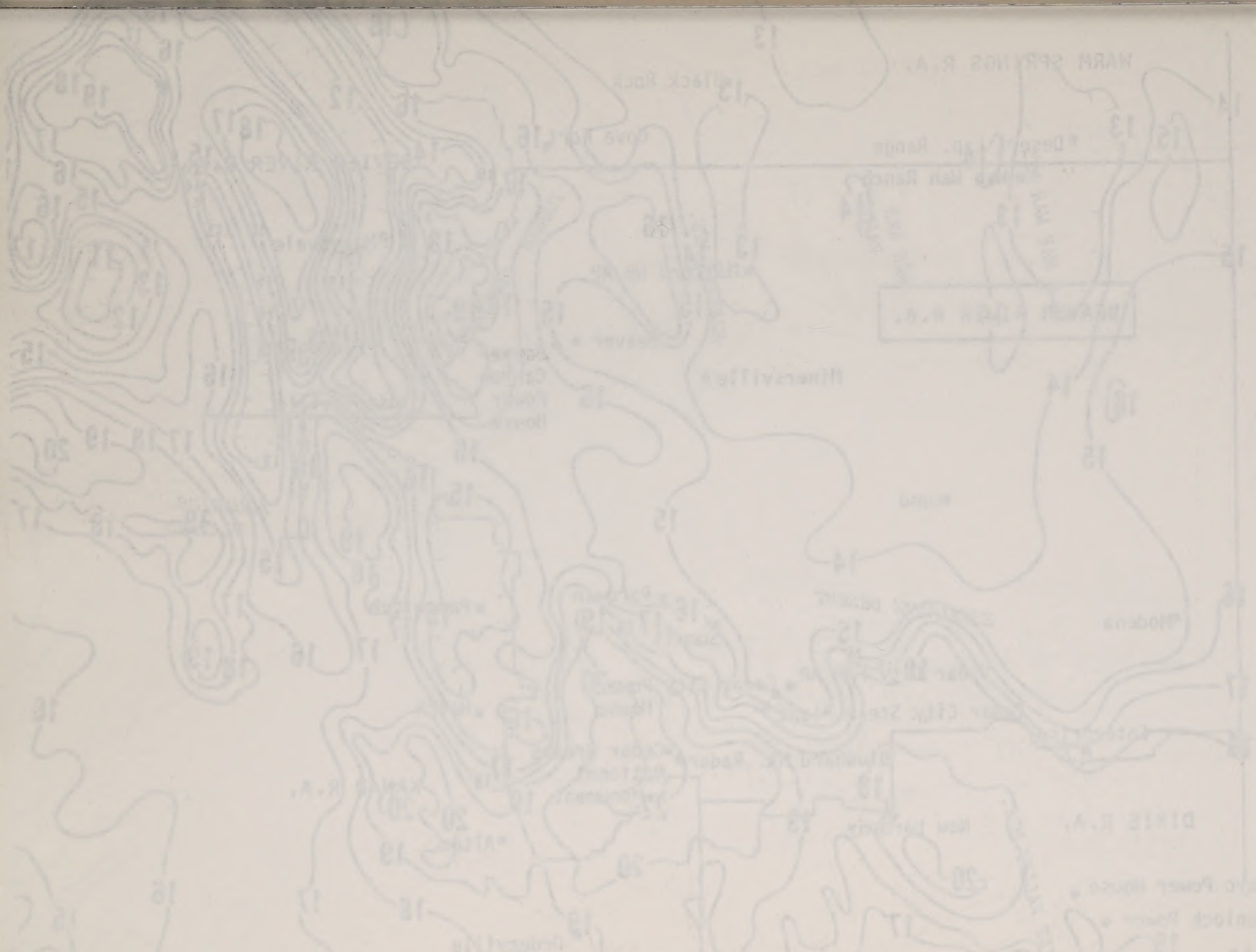

Figure 2.4-4
Isopluvial Analyses of Precipitation Amounts (10 years, 6 hours)
(tenths of an inch)

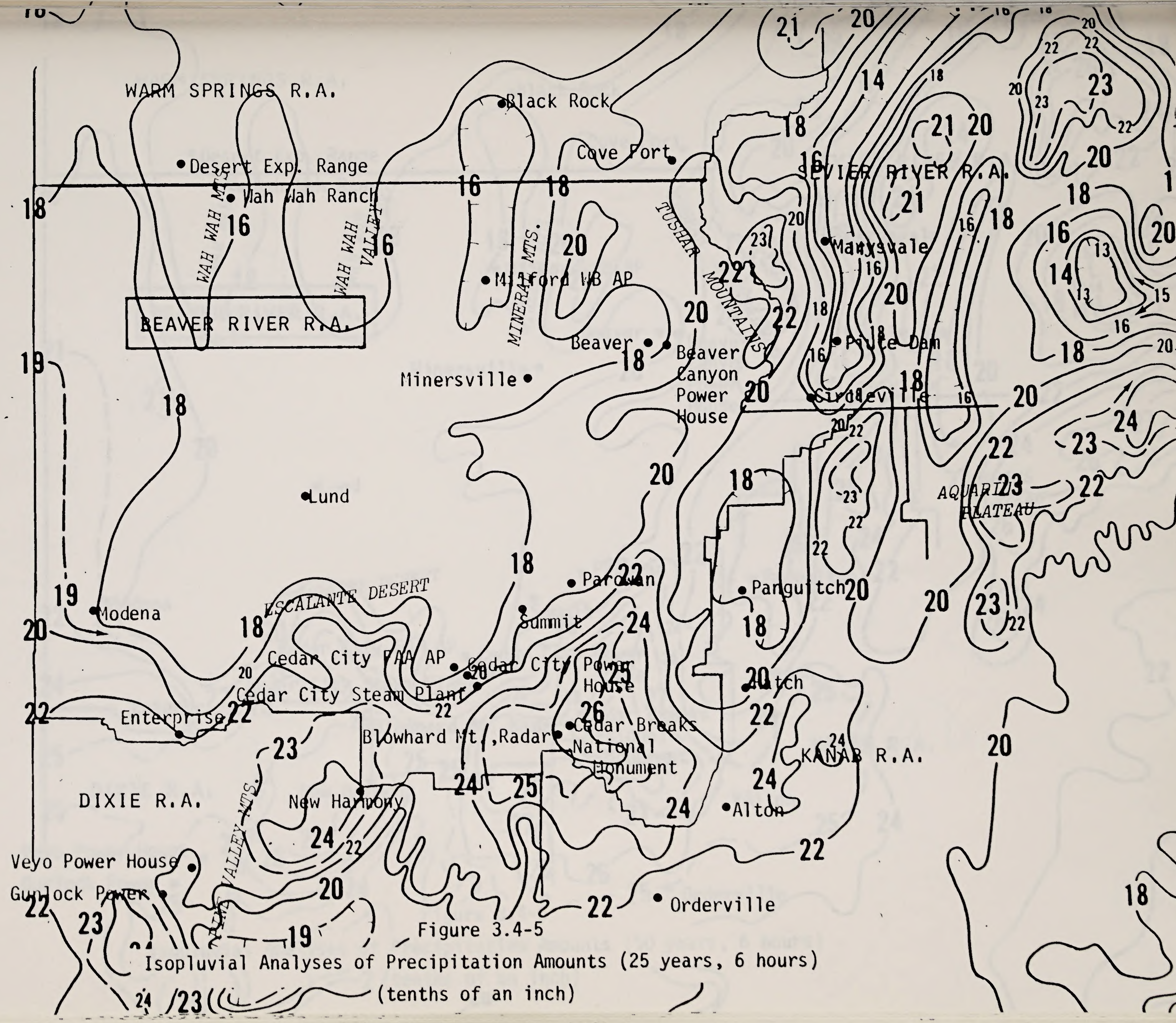

Figure 3.4-5
Isopluvial Analyses of Precipitation Amounts (25 years, 6 hours)
(tenths of an inch)

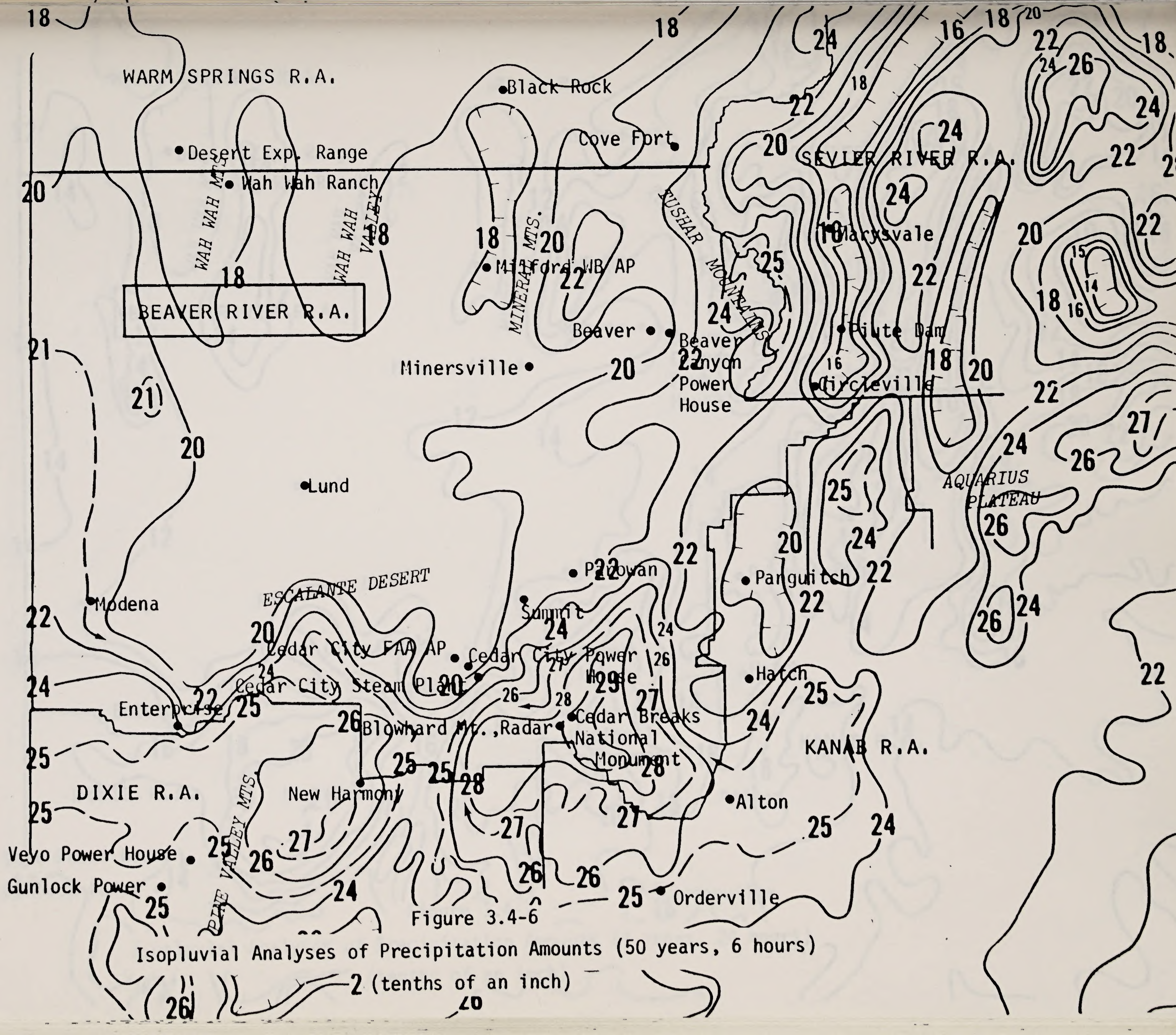

Figure 3.4-6

Isopluvial Analyses of Precipitation Amounts (50 years, 6 hours)

(tenths of an inch)

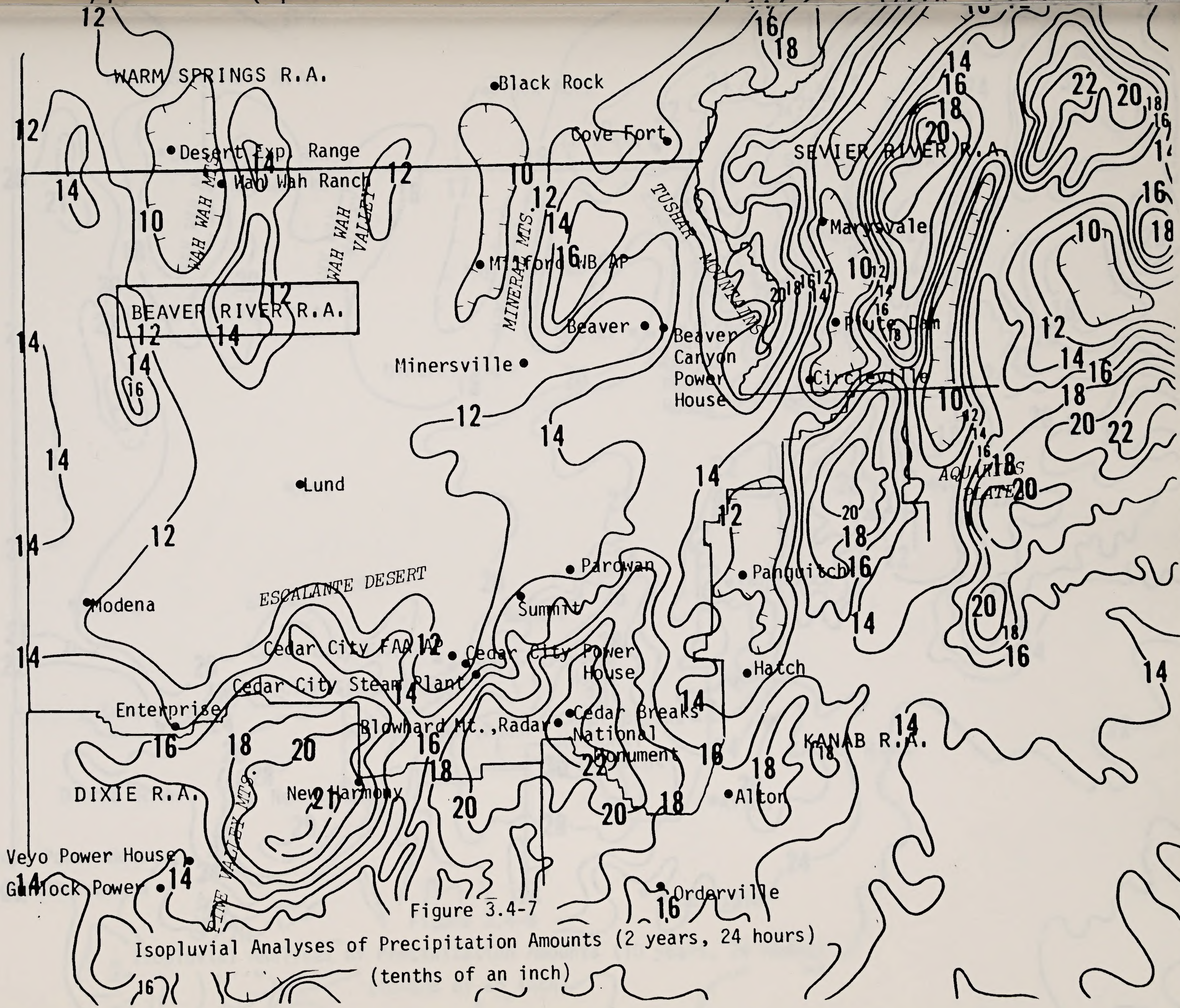

Figure 3.4-7

Isopluvial Analyses of Precipitation Amounts (2 years, 24 hours)
(tenths of an inch)

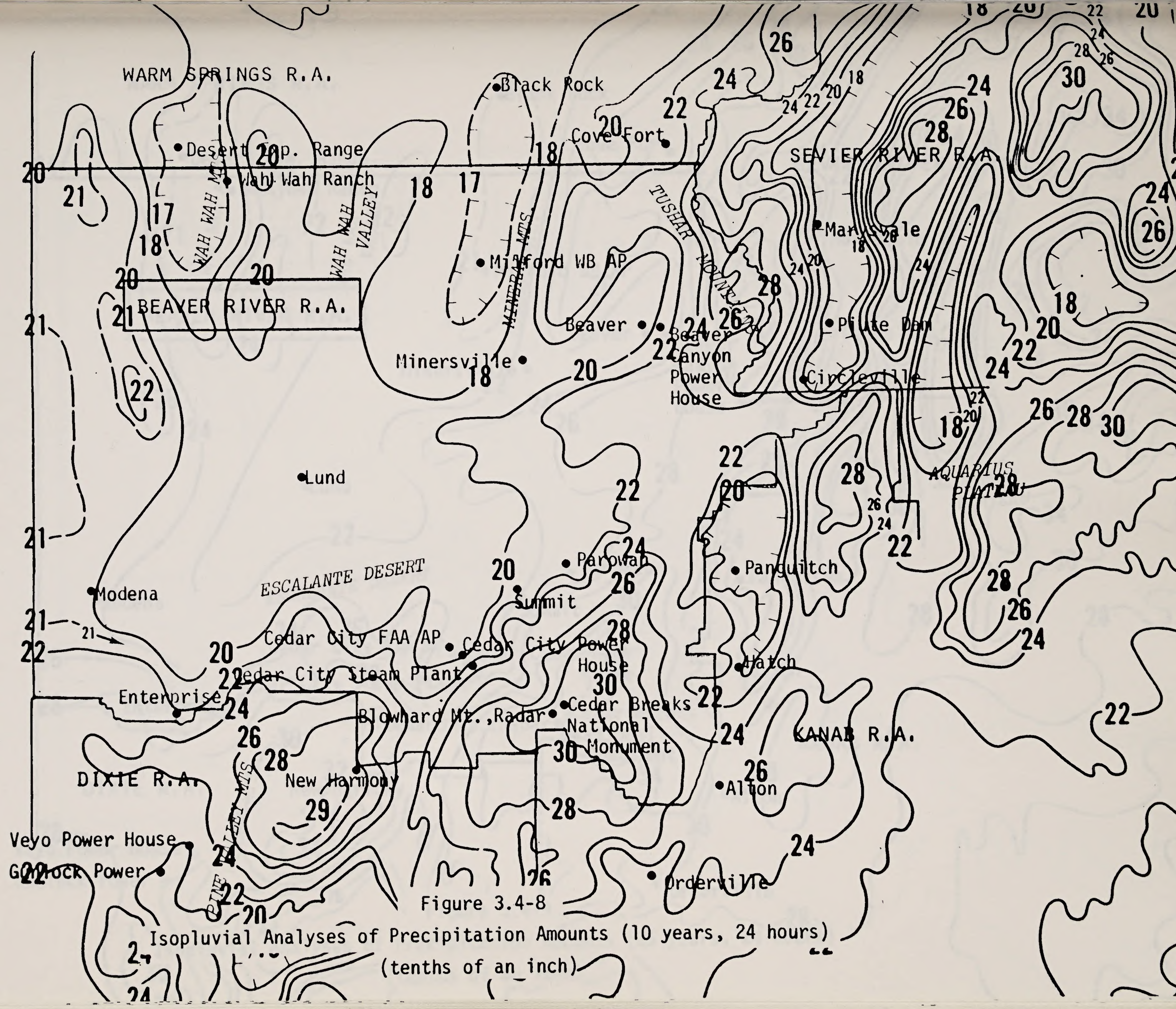

Figure 3.4-8

Isopluvial Analyses of Precipitation Amounts (10 years, 24 hours)

(tenths of an inch)

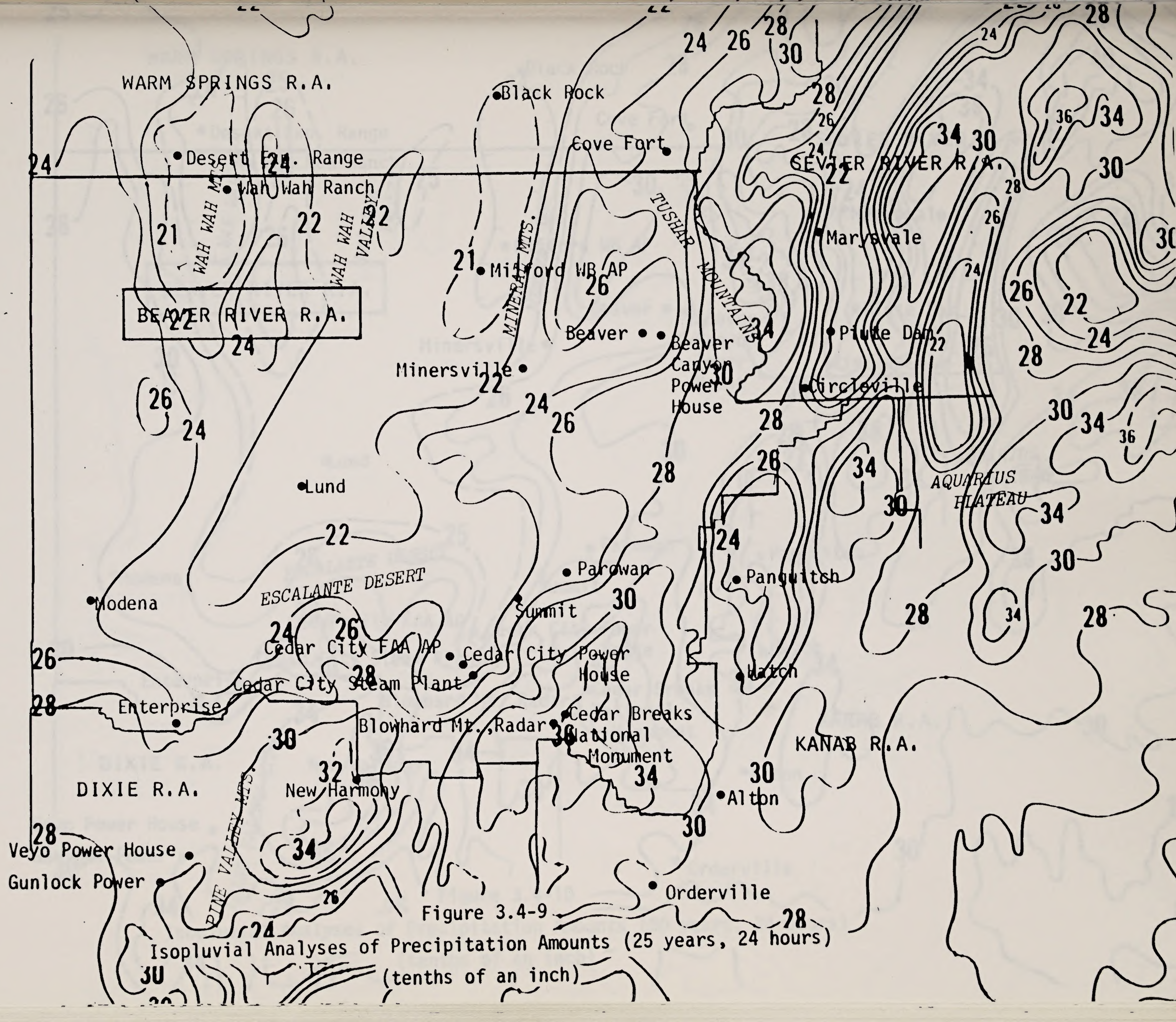

Figure 3.4-9

Isopluvial Analyses of Precipitation Amounts (25 years, 24 hours)
(tenths of an inch)

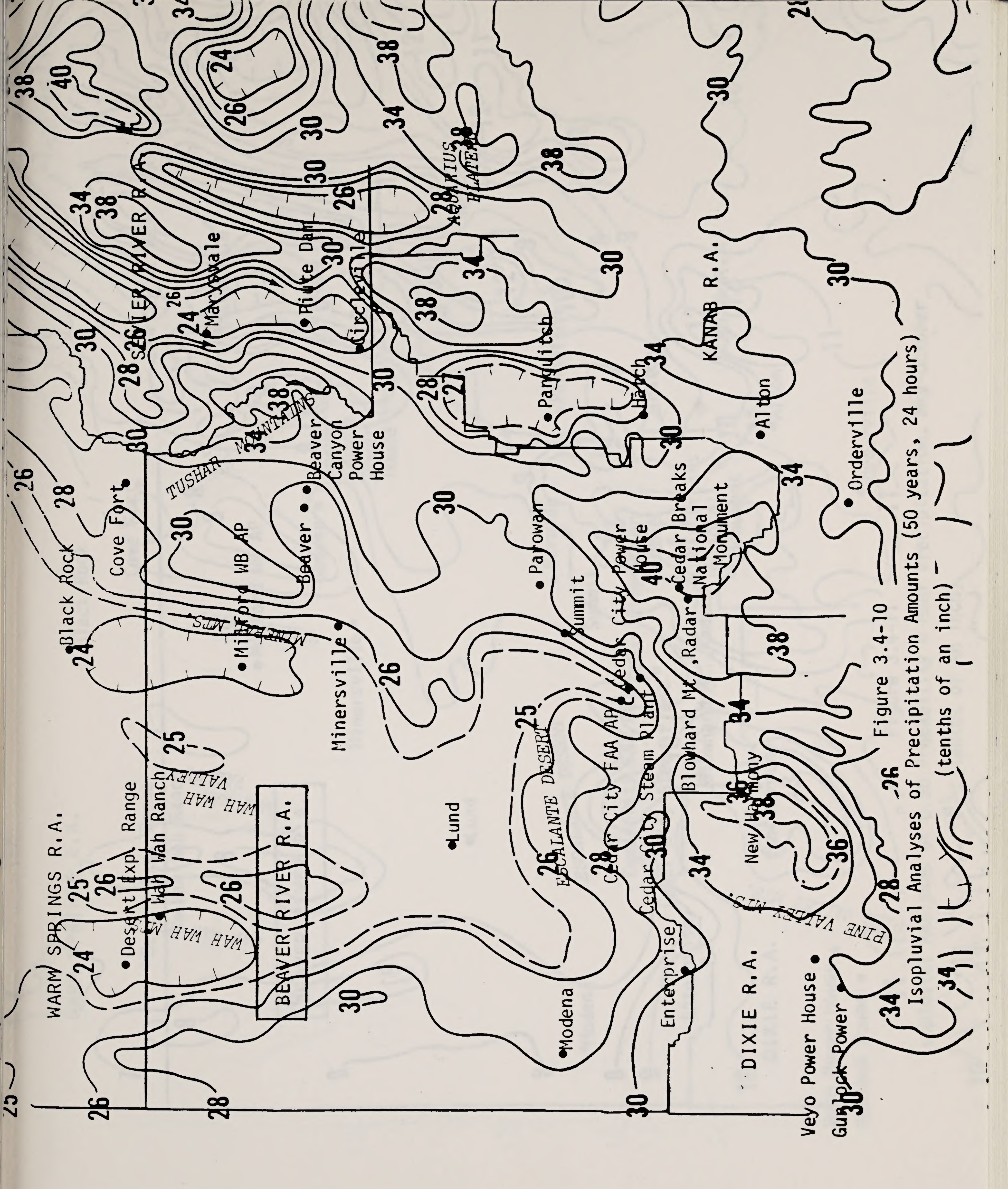

Figure 3.4-10 Isopluvial Analyses of Precipitation Amounts (50 years, 24 hours) (tenths of an inch)

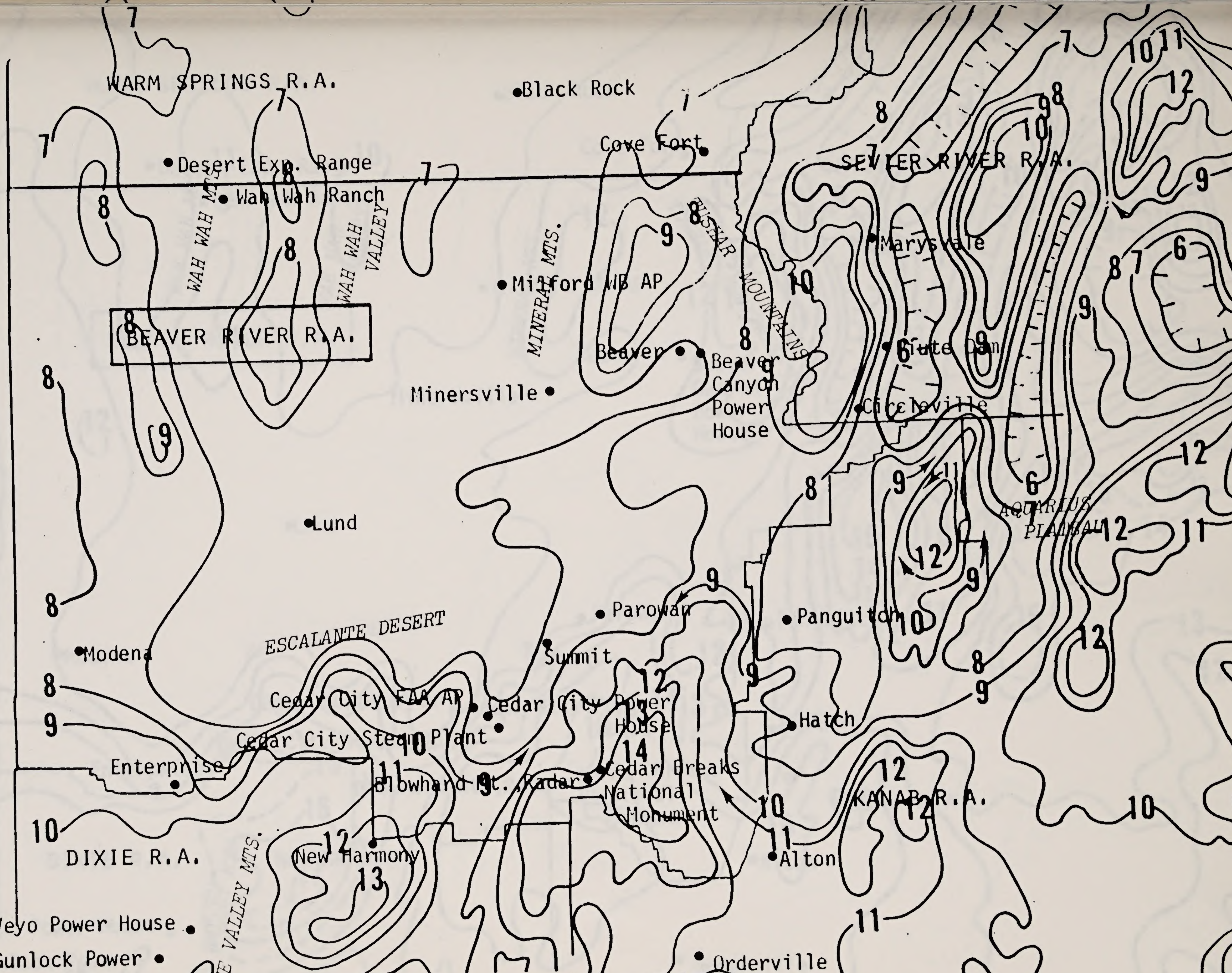

Figure 3.4-11

Isopluvial Analyses of 0.50 Probability 6 Hour Precipitation, May-October (tenths of an inch)

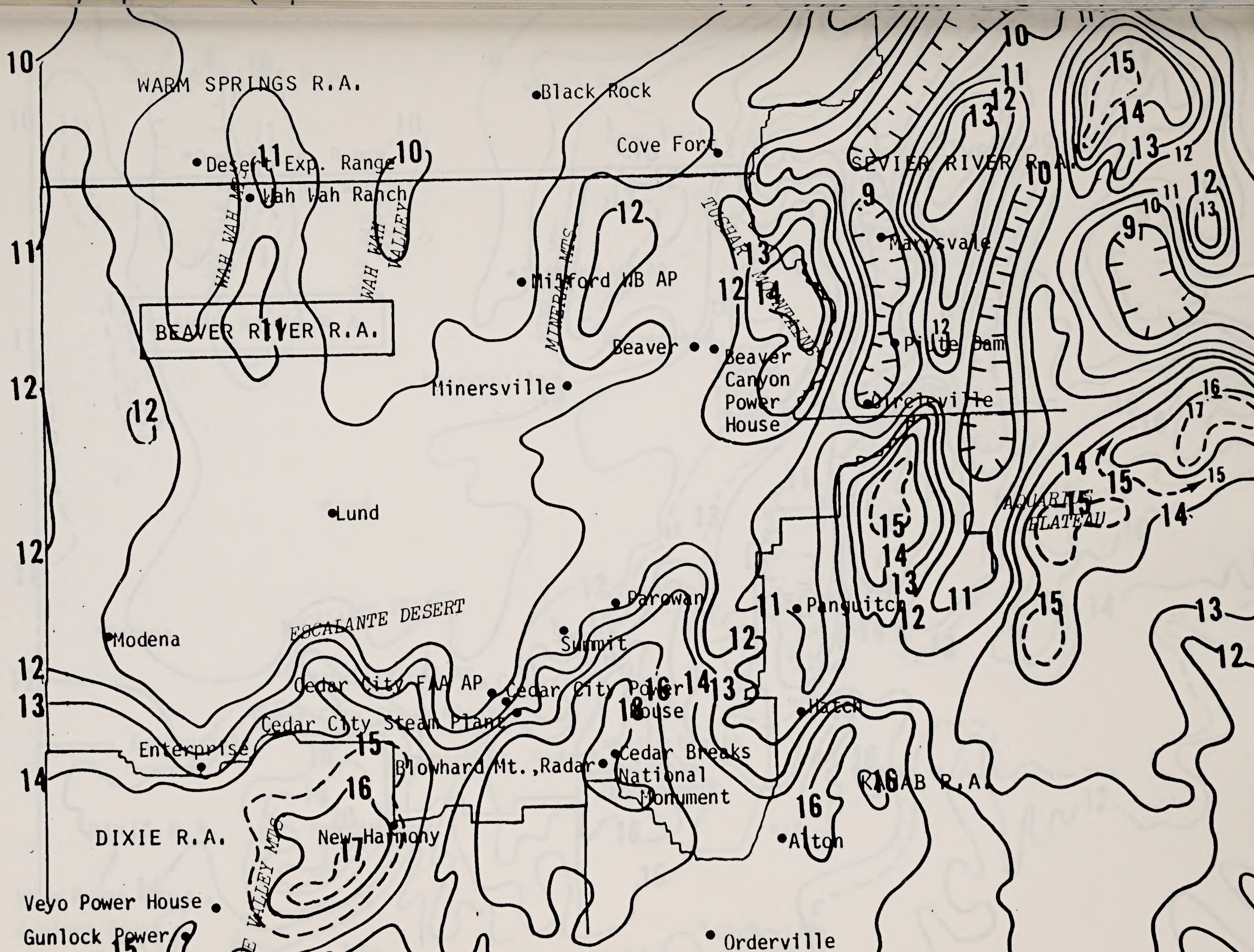

Figure 3.4-12

Isopluvial Analyses of 0.20 Probability 6 Hour Precipitation, May-October
(tenths of an inch)

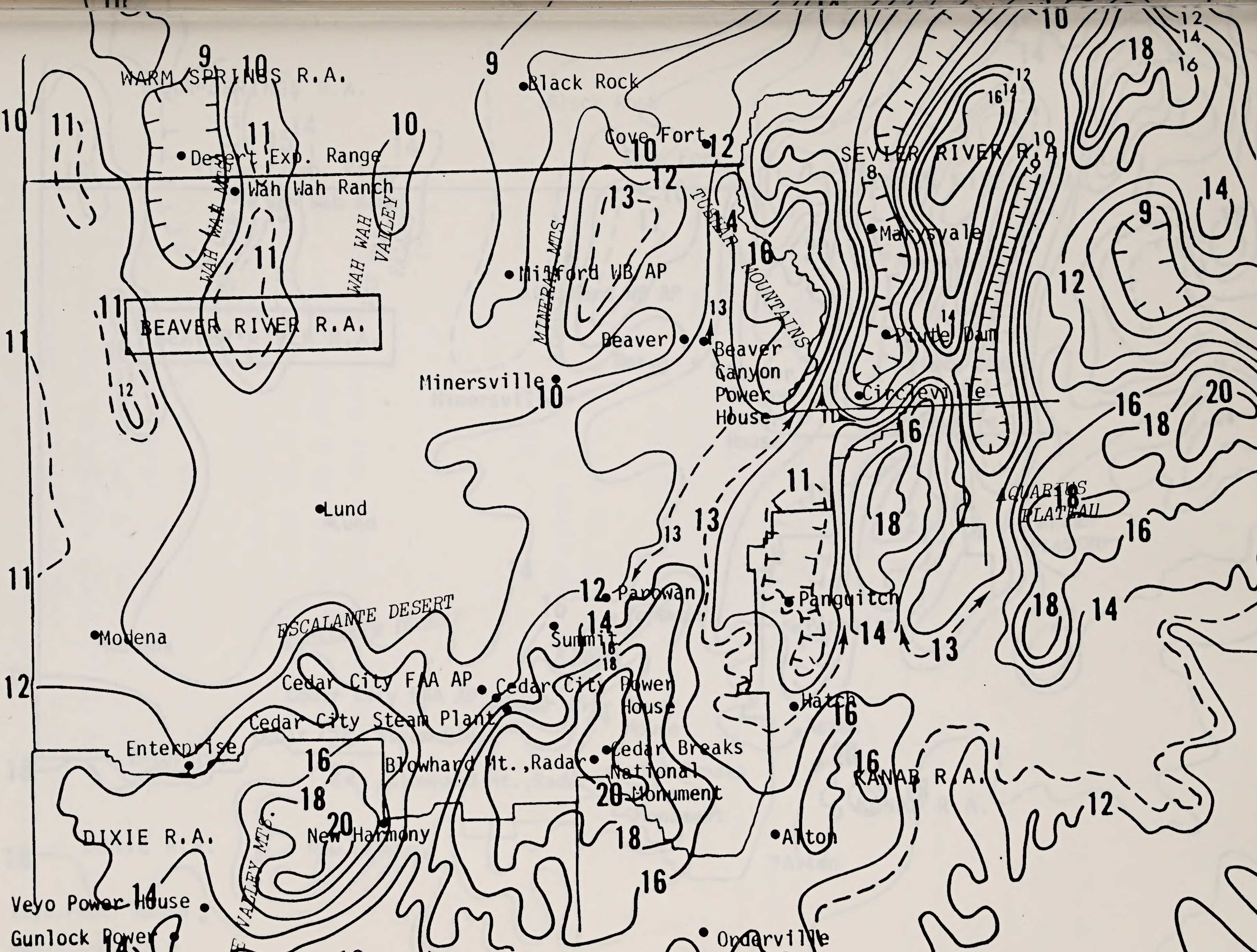

Figure 3.4-13

Isopluvial Analyses of 0.50 Probability 24 Hour Precipitation, May-October (tenths of an inch)

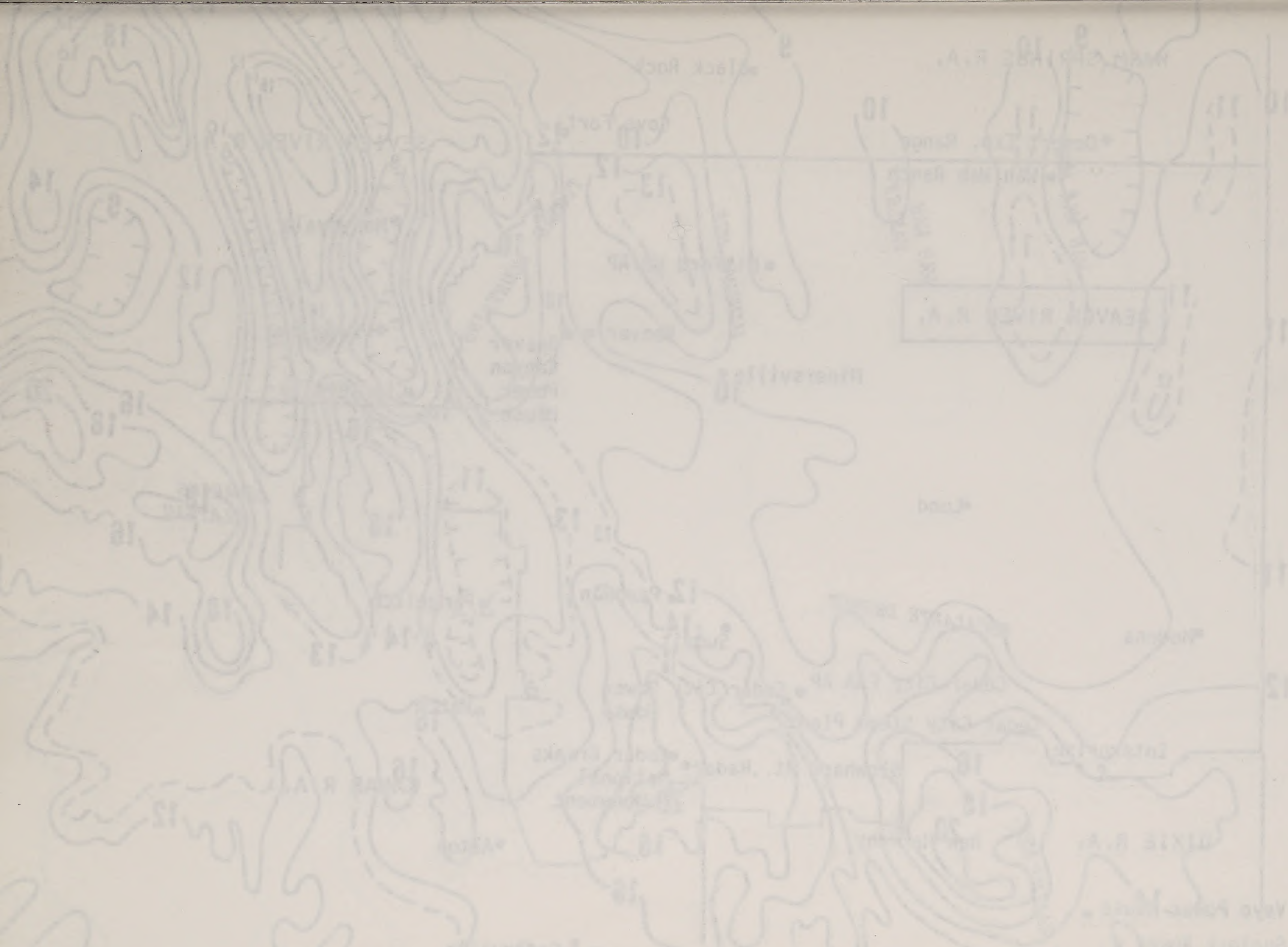

Figure 3.4-13

Isopluvial Analyses of 0.50 Probability 24 Hour Precipitation, May-October

(tenths of an inch)

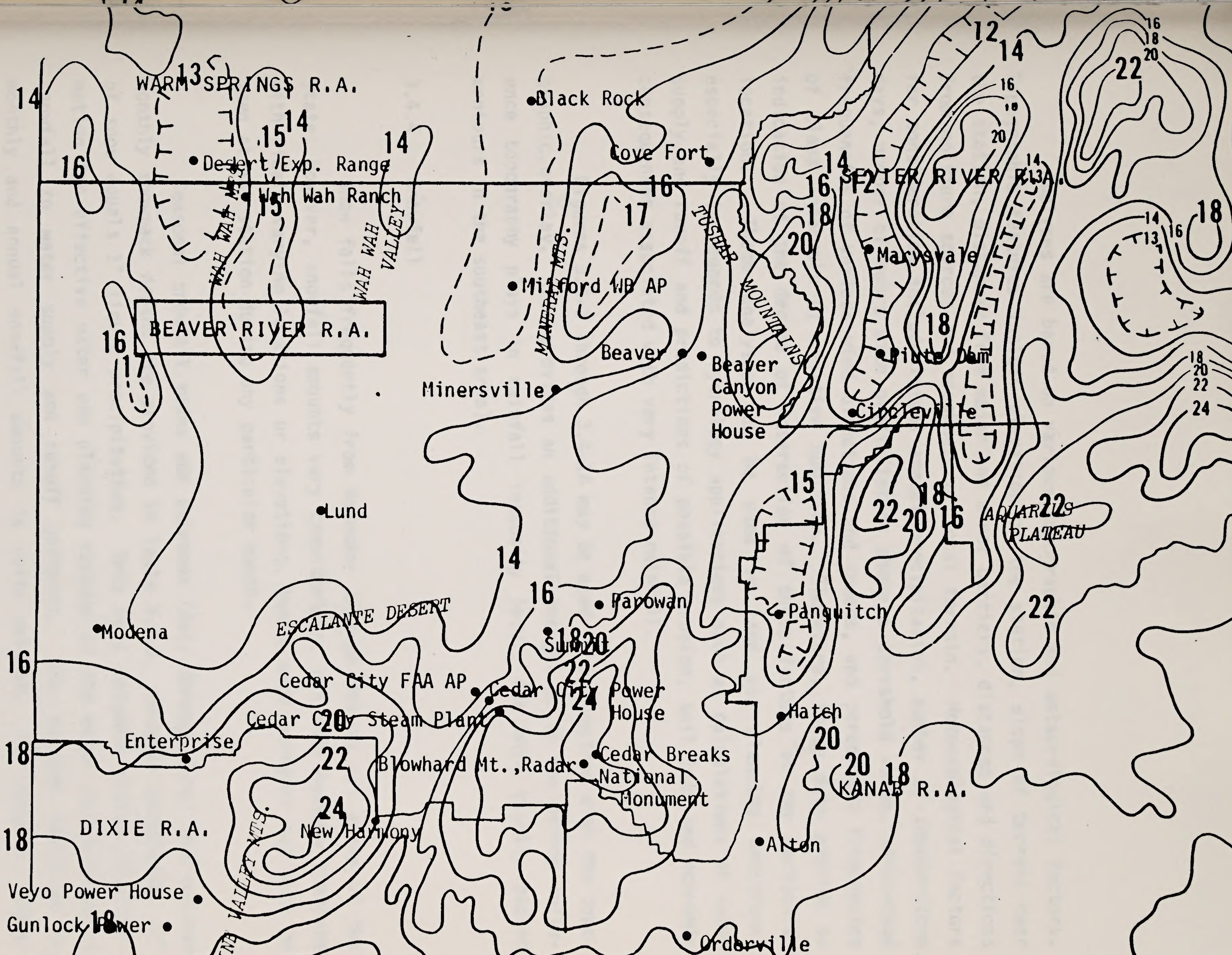

Figure 3.4-14
Isopluvial Analyses of 0.20 Probability 24 Hour Precipitation, May-October
(tenths of an inch)

Analyses are based on various topographic and meteorological factors. Topographic features include elevation of the station, slope of terrain near the station, distances from major and minor barriers, distances and directions from moisture sources and roughness of local terrain. Meteorological factors for consideration include normal annual precipitation, number of thunderstorm days, number of hours with precipitation above a threshold value, percentage frequencies of various wind directions and speeds, and percentage frequencies of class intervals of relative humidity. Therefore, these data provide an indication of the degree of interaction of these factors at any particular location. These analyses can be used in land use planning decisions, especially in regards to hydrology applications such as calculations of water supply and runoff and predictions of possible erosion, soil loss and economic consequenses associated with very intense rainfall.

Figures 3.4-3 through 3.4-14 may be used in conjunction with the topographic overlay. This provides an additional insight as to the strong influence topography plays in rainfall intensity (e.g., the more tightly packed contours in the southeast area).

3.4.4 Snowfall

Snow falls frequently from November through May in all areas of the State; however, snowfall amounts vary considerably, not only between stations with widely varying locations or elevations, but a wide variance may also be seen at any station during any particular month.

Seasonal snowfall means and extremes (July through June) and maximum monthly snowpack depths are provided in Table 3.4-3. Roughly translated, 12" of snow equals 1" liquid precipitation. This is a valuable source of information for effective water use planning because of the major contribution of snowfall to water supply and runoff patterns. The extreme deviation in monthly and annual snowfall amounts is quite evident. For example, annual

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3.4.4 Snowfall

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Seasonal snowfall means and extremes (July through June) and maximum monthly snowpack depths are provided in Table 3.4-3. Roughly translated, 10" of snow equals 1" liquid precipitation. This is a valuable source of information for effective water use planning because of the major contribution of snowfall to water supply and runoff patterns. The extreme deviation in monthly and annual snowfall amounts is quite evident. For example, annual

Table 3.4-3

Seasonal Snow Fall Means and Extremes

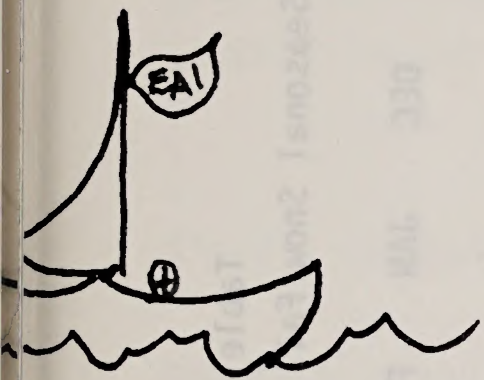
	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	ANNUAL+	MAX MONTHLY DEPTH	PERIOD OF RECORD
BLOWHARD MTN RADAR 10,690'															
Ext Max	0.0	1.0	9.0	13.0	63.3	68.5	90.0	102.5	50.0	94.0	35.5	17.5	355.9		1964 - 70
Mean Avg	0.0	0.1	2.3	4.4	29.5	46.0	41.5	36.1	35.2	48.2	12.1	5.2	260.6	148.0	1964 - 70
Ext Min	0.0	0.0	0.0	0.0	15.0	19.1	14.8	10.0	7.0	14.0	2.1	1.0	216.7		1964 - 70
CEDAR CITY 5610'															
Ext Max	0.0	0.0	2.0	13.5	13.7	23.4	23.8	34.2	28.1	23.7	6.8	T	67.4		1951 - 70
Mean Avg	0.0	0.0	0.1	1.3	4.7	7.0	6.9	7.3	7.8	5.8	0.7	0.0	41.6	13.0	1948 - 70
Ext Min	0.0	0.0	0.0	0.0	0.0	T	T	T	T	T	0.0	0.0	22.4		1951 - 70
CEDAR CITY STEAM PLANT 5980'															
Ext Max	0.0	0.0	0.0	0.0	11.0	14.5	11.6	13.5	19.1	11.3	4.0	0.0	45.2		1961 - 70
Mean Avg	0.0	0.0	0.0	0.0	3.9	11.8	5.2	8.0	10.2	4.1	1.1	0.0	44.3	11.0	1961 - 70
Ext Min	0.0	0.0	0.0	0.0	0.0	8.5	1.0	2.0	3.0	0.0	0.0	0.0	~~0.0~~ N/A		1961 - 70
ENTERPRISE BERYL JCT 5330'															
Ext Max	0.0	0.0	0.0	4.0	8.2	12.0	11.0	19.0	19.0	10.0	1.6	0.0	47.1		1961 - 70
Mean Avg	0.0	0.0	0.0	0.5	3.1	5.5	4.4	5.9	6.9	4.5	0.2	0.0	31.0	12.0	1961 - 70
Ext Min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.0	0.0	0.0	17.8		1961 - 70

TO THE **EAI** CREW :

PLEASE JOIN JOHN & CONNIE WILSON

FOR A

Harbor Boat Cruise



FRIDAY THE 13TH (ARE YOU SUPERSTITIOUS ?)

6:00 - COCKTAILS

6:30 - DEPARTING THE DOCK

PHONE: 224-1559

no
ostume
quired,
but
lress
warm

see over →

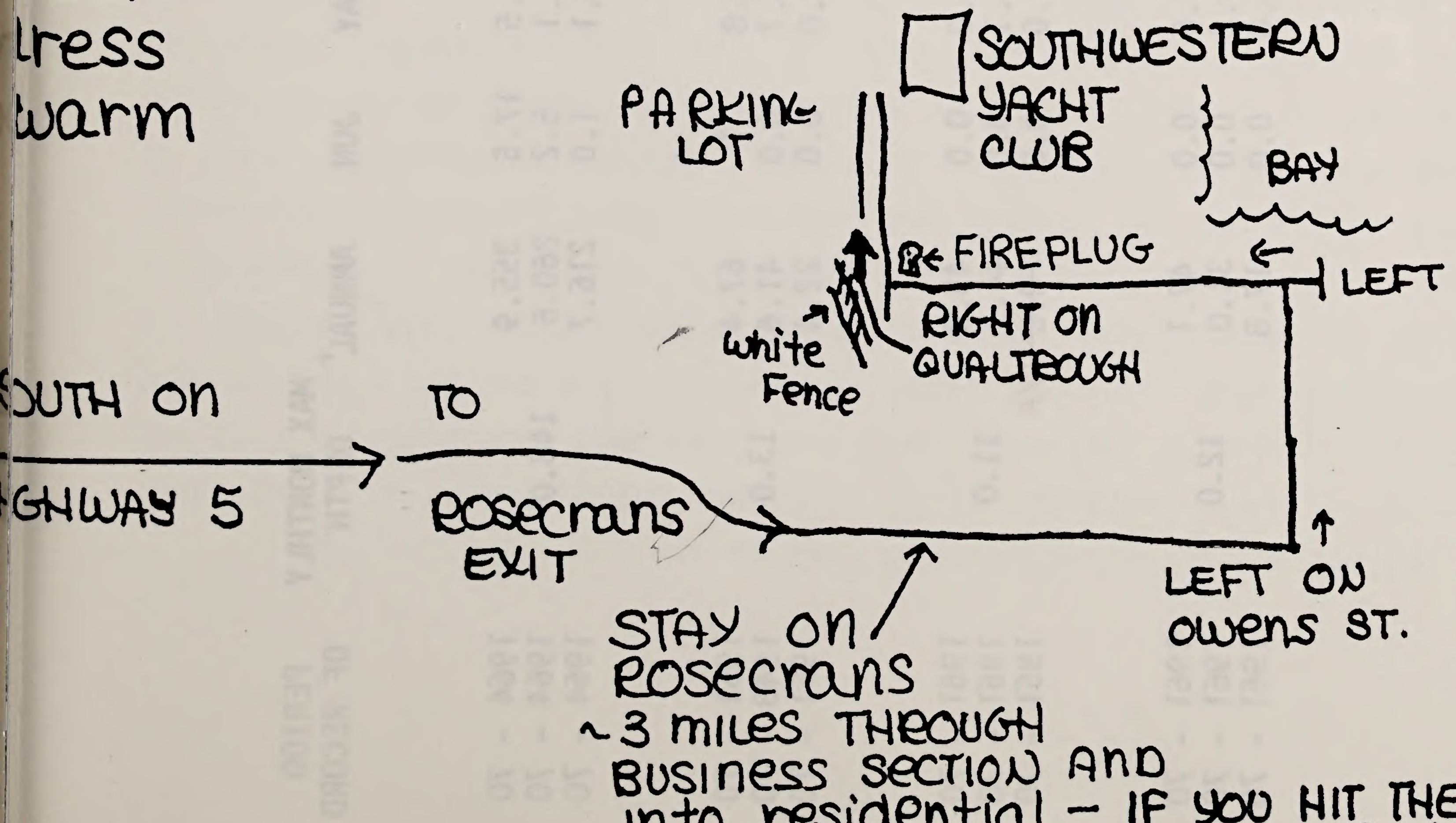


Table 3.4-3 (continued)

	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	ANNUAL+	MAX MONTHLY DEPTH	PERIOD OF RECORD
MODENA 5460'															
Ext Max	0.0	0.0	T	16.0	25.5	18.0	22.0	21.7	21.5	26.0	3.3	0.0	44.5		1951 - 70
Mean Avg	0.0	0.0	0.0	0.9	3.1	4.5	6.6	4.4	5.4	3.5	0.2	0.0	28.6	11.0	1914 - 70
Ext Min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.5		1951 - 70
MILFORD 5028'															
Ext Max	0.0	0.0	8.4	17.4	20.1	30.6	29.8	18.8	20.2	24.4	11.4	0.0	61.2		1902 - 70
Mean Avg	0.0	0.0	0.3	1.8	4.3	7.0	8.6	7.2	8.3	5.3	1.4	0.0	44.2	10.0	1951 - 70
Ext Min	0.0	0.0	0.0	0.0	0.0	T	T	T	0.0	0.0	0.0	0.0	29.9		1951 - 70
PAROWAN 5975'															
Ext Max	0.0	0.0	0.0	0.0	15.5	26.5	16.0	25.0	43.0	17.0	5.0	0.0	87.0		1961 - 70
Mean Avg	0.0	0.0	0.0	0.0	8.6	13.4	7.4	12.4	18.1	4.5	0.5	0.0	64.9	19.0	1961 - 70
Ext Min	0.0	0.0	0.0	0.0	0.0	3.0	2.5	7.5	5.0	0.0	0.0	0.0	34.1		1961 - 70
WAH WAH RANCH 4960'															
Ext Max	0.0	0.0	5.0	0.0	10.0	23.0	2.0	6.0	11.0	4.0	0.0	0.0	24.0		1961 - 70
Mean Avg	0.0	0.0	0.5	0.0	1.8	4.3	1.3	1.7	6.0	1.4	0.0	0.0	17.0	12.0	1961 - 70
Ext Min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	3.0		1961 - 70
BLACK ROCK* 4895'															
Ext Max	0.0	0.0	0.0	0.0	18.0	14.0	13.0	5.0	15.0	4.0	0.0	0.0	26.5		1960 - 70
Mean Avg	0.0	0.0	0.0	0.0	3.2	5.0	4.5	2.1	8.9	0.9	0.0	0.0	24.6	15.0	1960 - 70
Ext Min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0		1960 - 70
COVE FORT* 5700'															
Ext Max	0.0	0.0	0.0	0.0	8.5	23.3	11.1	19.6	19.1	2.5	1.0	0.0	75.6		1961 - 70
Mean Avg	0.0	0.0	0.0	0.0	1.7	8.1	7.4	11.8	12.0	0.9	0.1	0.0	42.0	10.0	1961 - 70
Ext Min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.9	0.0	0.0	0.0	0.0	0.0		1961 - 70

TO THE [illegible]

PLEASE JOIN JOHN COLLIE WILSON

FOR A

Harbor Boat Cruise

FRIDAY THE 13TH

6:00 COCKTAILS

6:30 DEPARTING THE DOCK

No costume required but dress warm

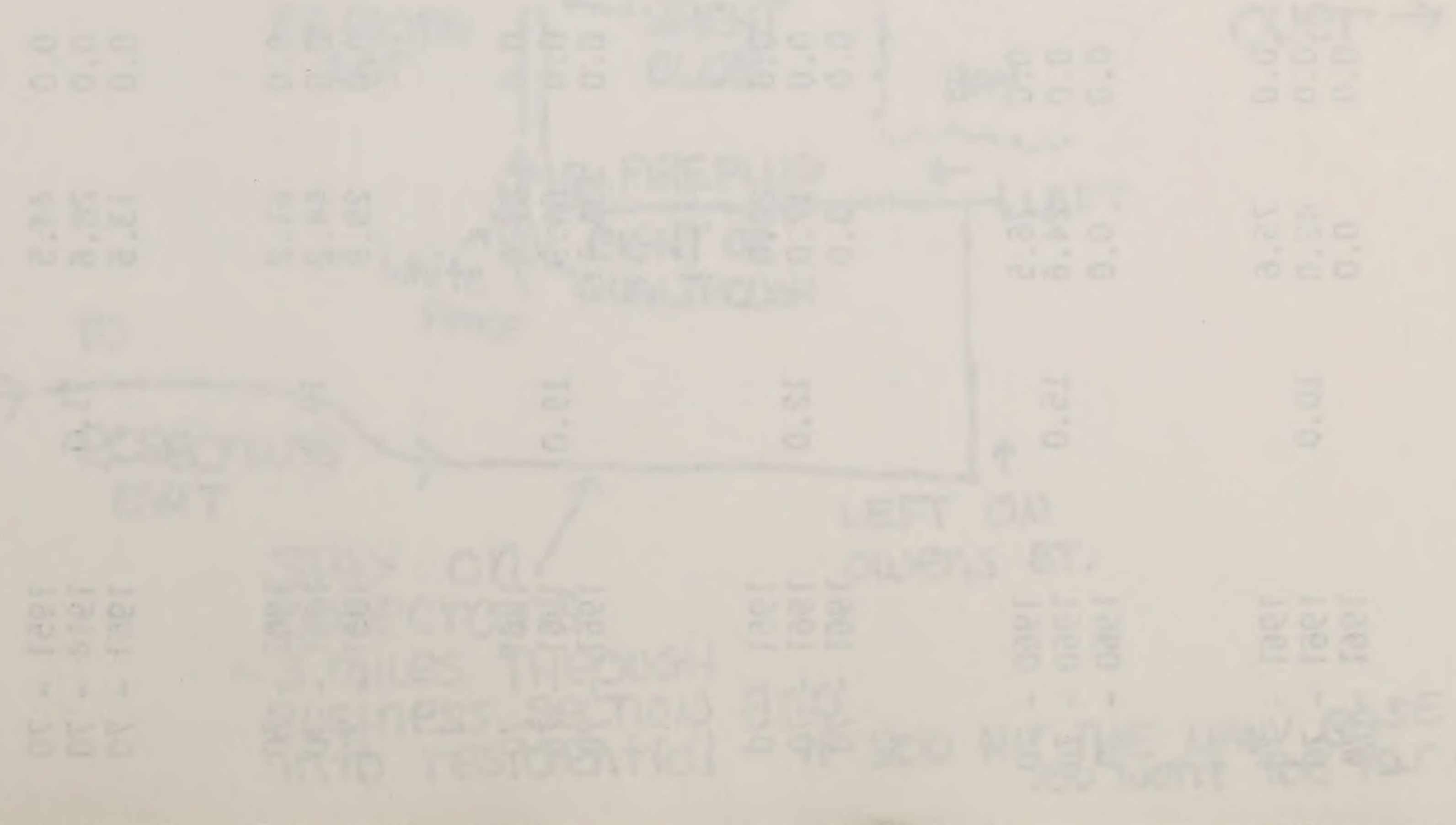


Table 3.4-3 (continued)

	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	ANNUAL+	MAX MONTHLY DEPTH	PERIOD OF RECORD
DESERT EXP RANGE *															
Ext Max	0.0	0.0	8.0	0.2	0.0	7.8	4.0	1.8	14.3	14.0	1.5	0.0	30.6		1960 - 70
Mean Avg	0.0	0.0	0.7	0.0	0.0**	2.9	1.3	0.9	4.2	2.1	0.1	0.0	12.2	11.0	1960 - 70
Ext Min	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0		1960 - 70

All Values in Inches

T = Trace = <0.01 inch

+ = Period of record for all annual maximum and minimum values varies slightly but falls within the years 1961 - 1970.

* = Representative of the R.A.
Source: National Climatic Center

** = Large periods of missing data may indicate values which are lower than they may actually be.

totals at Cove Fort have ranged from zero to over 75 inches, while average values are a more moderate 42 inches. Average annual snowfall amounts for the Beaver River R.A. are provided in Figure 3.4-15. The figure emphasizes the significant influence topography plays in determining snowfall amounts. The Tushar Mountains and the area near Cedar Breaks National Monument display values of 100 to 200 inches. The lower elevations of the Escalante Desert receive only 20 to 40 inches per year.

Table 3.4-4 provides the number of days with one inch or more of snow cover. As expected, those stations at higher elevations with greater western exposure have a greater number of days with one inch or more snow cover. In particular, Cove Fort, located above 5,700 feet MSL, experiences 64 days with snow cover. Stations in the Escalante Desert typically have less than 50 days with one inch snow cover.

3.4.5 Floods and Drought

It has been noted that precipitation amounts may vary considerably at any location in the Beaver River R.A.. This may be seen in Table 3.4-2 (monthly and growing season means and extremes of precipitation) and Table 3.4-3 (means and extremes of snowfall). Any unusually large precipitation events or series of events during a short time span may result in localized flood conditions. Heavy spring rains, which contribute to rapid snow melt, are a prime cause of flooding in Utah. Also, thunderstorms often cause flash floods in this area of Utah. These occur most frequently from July through September. Soil loss and erosion and economic losses due to flash floods can often be devastating. Table 3.4-5 outlines flood events as reported by the Utah State Climatologist.

Although not indicated in Table 3.4-5, an area of present concern is Blawn Wash Canyon, about six to eight miles north of Lund. Flash flooding, probably due to intense rainfall during the summer of 1980, had contributed to large scale flash flooding. This resulted in the formation of an active cut

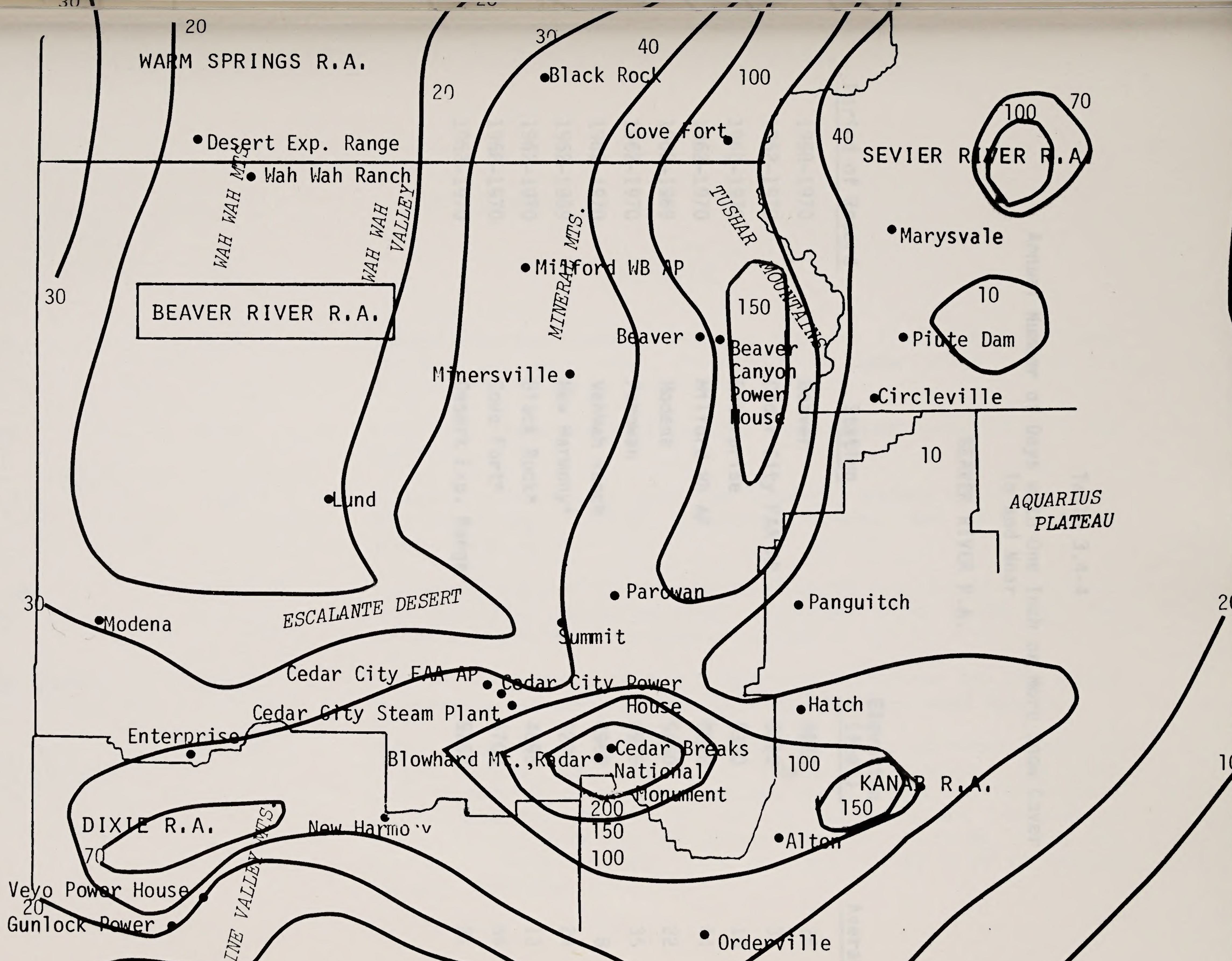


Figure 3.4-15
Average Annual Snowfall in the
Beaver River R.A.

Table 3.4-4

Annual Number of Days with One Inch or More Snow Cover
In and Near

BEAVER RIVER R.A.

Period of Record	Station	Elevation (feet)	Average
1968-1970	Beaver	5860	26
1962-1970	Cedar City FAA AP	5610	33
1962-1970	Enterprise	5330	18
1962-1970	Milford WB AP	5028	44
1962-1969	Modena	5460	22
1962-1970	Parowan	5975	35
1962-1970	WahWah Ranch	4960	8
1962-1969	New Harmony*	5290	24
1962-1970	Black Rock*	4895	13
1968-1970	Cove Fort*	5700	64
1963-1970	Desert Exp. Range*	5252	21

*Representative of R.A.
Source: National Climatic Center

Table 3.4-5

Review of Historical Occurrences of Floods

BEAVER RIVER

Location	Date	Description
Southern Utah	7/53	Drought-stricken southern Utah was hit with flash floods. Damage was heaviest near Levan, Richfield and Cedar City. Road and railroad damage was estimated at $25,000.
Southern Utah	9/54	A general storm hit Utah causing flash floods especially in the southeast.
Cedar City	7/56	A flood hit Cedar City requiring volunteer workers to build a dam. Many lawns were buried, basements flooded, and debris strewn across local roads.
Emery, Kane and Iron Counties	9/8-9/61	Scattered, heavy thunderstorms resulted in considerable flooding. Most extensive damage occurred near Green River where over two inches of rain fell in a 24-hour period.
Parowan, Iron County	8/2/63	A flash flood caused by heavy thunderstorms caused $40,000 damage to highways and campground in Dry and First Left Hand Canyons.
Sevier, Iron, Utah and Salt Lake Counties	8/17/65	Local flash floods associated with heavy thunderstorm activity caused serious damage to homes, fields and highways. In Cedar City, a portion of the cemetery was washed away and the highway was blocked for several hours. In Annabella and Glenwood in Sevier County, over $18,000 damage was done to farms, roads and bridges. Young orchards were destroyed along with irrigation ditches, pipelines and pumps.

Table 3.4-5 (cont'd)
Review of Historical Occurrences of Floods

BEAVER RIVER

Location	Date	Description
Northern Utah Counties and Zion National Park	9/5/65	Severe thunderstorms swept across many sections of the State Sunday afternoon and evening leaving death and destruction in their wake. Local floods hit southern Salt Lake County and a flash flood in the Zion Narrows in Zions National Park trapped 45 hikers for several hours. Many of the hikers were injured but all made their way to safety when the water finally receded.
Washington, Kane and Iron Counties	12/4-6/66	Record breaking rainfall in southwestern Utah during the 4th, 5th and 6th of December resulted in heavy damage to buildings, farmlands, and crops. The Virgin River rose 12 feet below Zion Narrows, which washed out new campgrounds and the amphitheater at Zion National Park, swept out utility and telephone lines, and washed out two bridges isolating the community of Springdale. Farmland were severely damaged as flood waters left 6 to 10 feet of silt on fields, washed away haystacks and unharvested sugar beets.
Cedar City to Salt Lake City	7/16/67	Heavy thunderstorms and shower activity during the afternoon resulted in considerable local flooding at several areas along the Wasatch Front. Most serious flooding occurred in Salt Lake City and Cedar City. Lightning damaged transformers and power lines. Winds up to 47 miles per hour as measured at the Salt Lake Airport, uprooted trees and damaged signs.
Monroe Canyon, Sevier County	7/9/70	A flash flood resulting from heavy rains above Monroe Canyon caused extensive damage to the local power plant and a water line, about $20,000 damage to the park and highway, and flooding of local farmland. Total damage was estimated near $75,000.

Table 3.4-5 (Cont'd)

Review of Historical Occurrences of Floods

BEAVER RIVER

Location	Date	Description
Saint George	8/14-15/66	A heavy thunderstorm on the east side of town deposited 1.25 inches of precipitation within an hour on the 14th of the month and 0.45 inches within a half hour on the 15th which produced minor damages to streets, irrigation works and machinery plants. Damage was estimated at $22,500.
Salina	8/20/70	Flooding on August 20th produced substantial damage when heavy rains fell on two ravines east of town. Rainfall of 1-1/2 inches occurred in town between 10:30 and 11:00 p.m. with estimates of over 2 inches in the foothills during a 20 to 40 minute period.
Salina	8/26/70	Flooding resulted in minor damage, about $13,000 to urban and commercial dwellings when rain swollen Salina Creek moved through town.
Zion National Park	6/16/72	Heavy afternoon thunderstorms produced flash flooding and mud slides at Park Headquarters blocking the main roads for several hours.
Zion National Park	6/22/72	For the second time in a week a heavy storm hit the headquarters area of Zion National Park blocking roads with mud slides. This second storm was more extensive and caused more damage than the storm of the 15th. Flood damage extended to Rockville and Springdale.

or gulley at the canyon bottom and well developed rills down the canyon slopes. Because of the active cut and developed rills, flooding may occur in the future with less intense storms and thus may become a reoccurring problem (Wiley, 1981).

Likewise, when minimal precipitation amounts occur over a wide area for a significant period of time, drought conditions will result. This is a fairly common occurrence in the State and usually encompasses a large area for up to a year or more; however, no description of drought conditions are presently available.

3.5 EVAPORATION AND RELATED PARAMETERS

Evaporation describes that portion of the hydrological cycle responsible for the return of moisture from the earth to the atmosphere. Evaporation is an important climatological parameter in terms of both land use and engineering design. In an arid area, such as Utah, potential evaporation (a measure of the degree to which the weather or climate of a region is favorable to the process of evaporation) is much greater than in a humid area. Many climatological factors affect evaporation rates. These factors include solar radiation, wind, the vapor pressure difference between the air and evaporating water, the nature and area of evaporating surface (e.g., soil, vegetation, snow and ice) and finally, the availability of water or humidity of the air (Lewis, 1978).

The task of measuring evaporation is quite difficult considering the number of factors which must be considered. Therefore, in order to better understand moisture exchange between the earth and atmosphere, the following concepts will be evaluated: pan evaporation and lake evaporation.

3.5.1 Pan Evaporation

Pan evaporation describes the most common technique for determining evaporation amounts. It is actually the amount of water vapor to escape from a U.S. Weather Bureau Class A evaporation pan. Pan evaporation measurements have been taken at a few stations in the Beaver River R.A. Monthly evaporation amounts can be found in Table 3.5-1.

Evaporation amounts within Utah are limited by precipitation values. Maximum evaporation rates generally occur during the summer months especially in July, when the incidence of solar radiation is generally at a maximum. Minimum values can be expected during the winter months, when solar radiation is at a minimum. In fact, evaporation amounts are so minimal and sublimationn (the changes of ice to water vapor) is so difficult to detect that evaporation measurements in Utah during the winter months are not available.

Table 3.5-1

Pan Evaporation Means and Extremes (Inches)
In and Near

BEAVER RIVER R.A.

Station & Elevation (feet)		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	April_oct
Milford (1953-1970) 5028'	Mean	-	-	-	7.64	10.80	13.53	15.52	13.43	10.19	6.41	2.58	-	72.52
	Max	-	-	-	9.48	12.79	16.57	18.21	16.23	12.42	7.33	-	-	
	Min	-	-	-	6.06	7.51	9.96	12.32	10.10	8.09	4.49	-	-	
Piute Dam* (1941-1970) 5900'	Mean	-	-	-	6.34	8.27	10.05	10.22	8.70	7.38	4.64	-	-	55.6
	Max	-	-	-	7.28	9.64	12.32	12.18	10.92	8.41	6.56	-	-	
	Min	-	-	-	4.91	6.66	7.87	8.13	4.58	5.32	2.44	-	-	

*Representative of the R.A.
Source: National Climatic Center

May to October pan evaporation rates for the Beaver River R.A. are analyzed in Figure 3.5-1. Highest pan evaporation amounts, about 70 inches, are seen in the Wah Wah Valley. Lowest amounts are seen in the higher elevations east of Cedar City, these being about 30 inches. Means and extremes of pan evaporation for the 32° freeze-free season are provided in Table 3.5-2. Of these stations reporting, Milford experiences the highest amount of evaporation and also the most deviation from the mean value. This would be typical of more arid areas of the Beaver River R.A., such as the Escalante Desert and Wah Wah Valley.

3.5.2 Lake Evaporation

Lake evaporation is another important parameter to be considered for water management. Values for lake evaporation may be derived from pan evaporation rates based on the principal that evaporation from small lakes (e.g., an evaporation pan) is greater than that from larger lakes. Such variations are caused by the difference in heat storage capacity. The surface temperature of a larger or deeper reservoir will not increase as readily as that of a more shallow reservoir. The cooler water surface temperature will suppress evaporation. A comparison of evaporation rates at two adjacent lakes in Nevada has been conducted by Harding (1962). Study results have been summarized in Table 3.5-3.

These rates, however, do not apply to salt water lakes. Lake salinity is another factor which affects evaporation rates. A traditional long-term estimate by Adams (1934) of 37.7 inches is in close agreement with estimates by Peck and Dickson (1965) which is quite useful for determining evaporation rates for the Great Salt Lake (Hughes, 1974). May through October lake evaporation rates are provided in Figure 3.5-2. The figure shows rates averaging from 20 inches in the eastern highlands to 40 inches in the western extremes of the R.A.

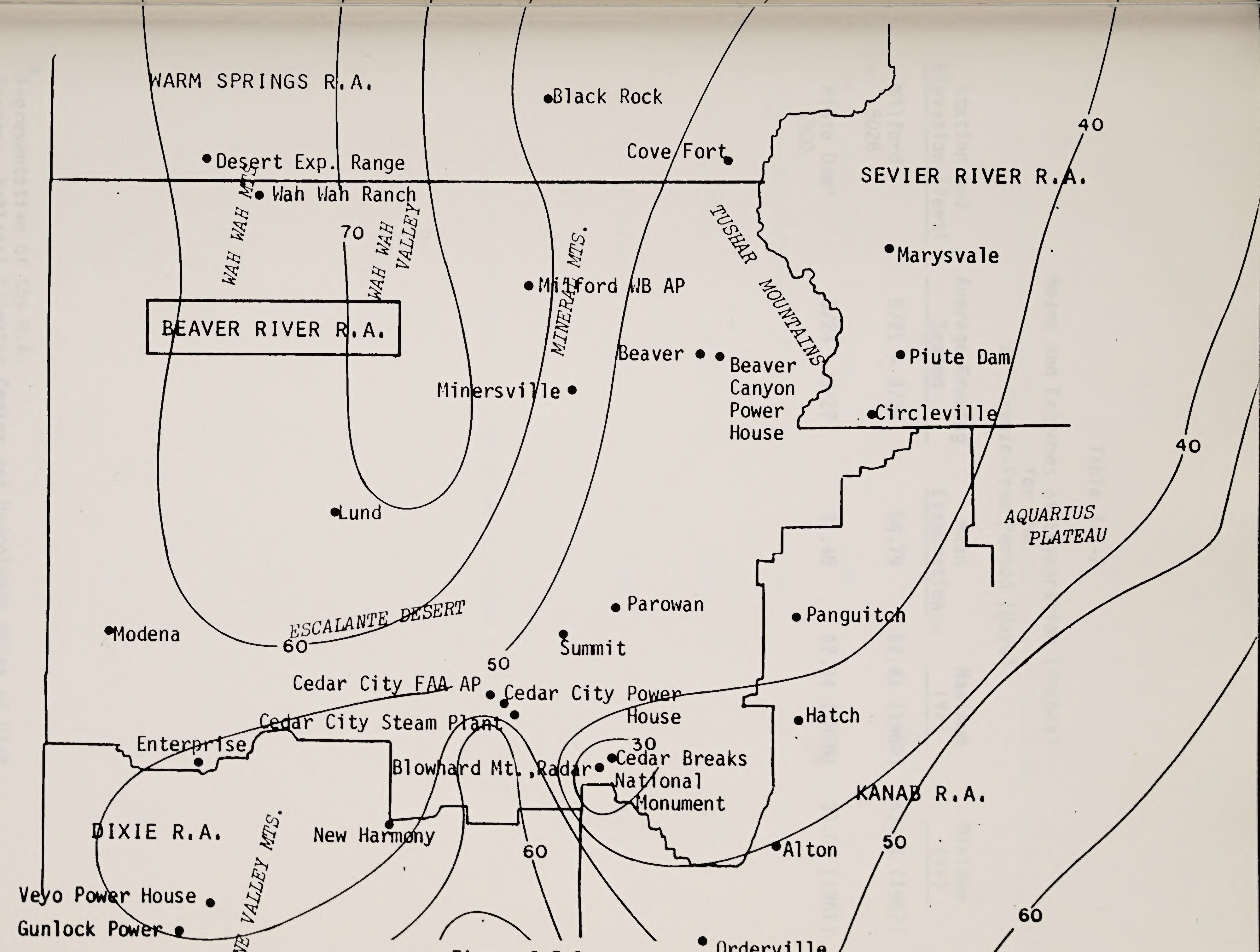


Figure 3.5-1

May to October Pan Evaporation
(Inches)

Source: Water Salvage Potentials in Utah

Table 3.5-2

Means and Extremes of Evaporation (Inches) for the 32° Freeze-Free Period (Days)

Station and Elevation (feet)	Average Growing Season	Mean Evaporation	Maximum (Yr)	Minimum (Yr)
Milford 5028	5/21 - 9/26	54.79	62.41 (1960)	43.26 (1967)
Piute Dam* 5900	5/24 - 9/27	37.48	42.34 (1960)	33.07 (1961)

*Representative of the R.A.
Source: National Climatic Center and Hydrologic Atlas of Utah

Table 3.5-3

Effect of Reservoir Depths on Lake Evaporation Rates (Inches)

Period	Deep Lake (200')	Shallow Lake (15')	Ratio Deep/Shallow
March-August	1.88	3.03	0.62
September-February	2.14	0.95	2.25
May-October	2.45	3.31	0.74
Total for Year	4.02	3.98	1.01

Source: Harding (1962) as cited in Hughes (1974).

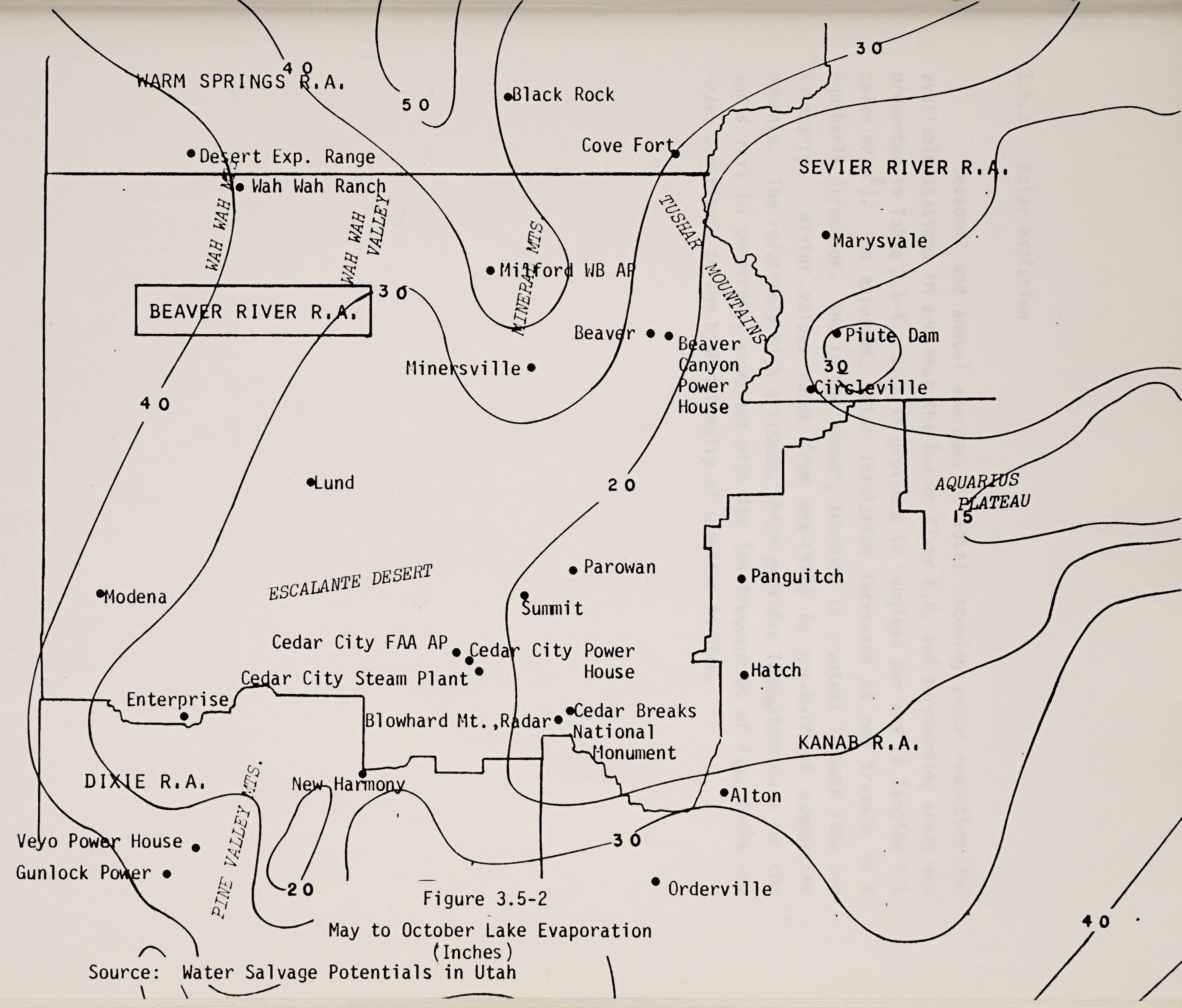


Figure 3.5-2

May to October Lake Evaporation
(Inches)

Source: Water Salvage Potentials in Utah

3.5.3 Solar Radiation

Seasonal and annual averages of total incoming solar radiation for available stations in and near the Beaver River R.A. and surrounding areas are presented in Table 3.5-4. Data is provided in langleys per day (1 langley = 1 calorie/cm^2). As expected, solar insolation increases as one travels in a southerly direction. And in the summer, sunshine is greatest in both time and intensity. Winter values range from one-third to one-half of summertime amounts. The relatively high altitude, which provides less atmosphere for the sun's rays to penetrate, combined with the low frequencies of fog, smoke and haze, contribute to the high intensity of sunshine in Utah.

Table 3.5-4

Seasonal and Annual Averages of Mean Daily Solar Insolation
(Langleys/Day)

BEAVER RIVER R.A.

Location	Winter	Spring	Summer	Fall	Annual
Cedar City	257.5	560.1	673.6	399.7	472.7
Yucca Flats*	278.4	595.6	702.4	414.1	497.6
Ely*	242.6	535.8	650.1	386.0	453.6

*Representative of the R.A.
Source: "Input Data for Solar Systems".

3.6 SEVERE WEATHER

3.6.1 Hail

Hail results from the formation of irregular chips of ice which are produced by convective activity in clouds, such as in cumulonimbus types. Thunderstorms, which are characterized by strong updrafts, high water content, large cloud drop sizes, and great vertical height, offer great potential for hail and ice formation, which is a very common phenomenon in Utah and may have considerable influence on short-term BLM land use alternatives. Hail can range in size from that of a small pea to softball size and larger. Table 3.6-1 presents the incidence of hail and estimates of damage when available as recorded by the State Climatologist.

3.6.2 Dust and High Wind Events

Dust storms, and more often high winds, may cause severe property and crop damage in the State. Historical data on dust storms has been provided in Table 3.6-2 as recorded by the State Climatologist. Although data is insufficient, dust may be severely crippling to the agricultural economy of the State, especially during drought conditions and may occur in virtually any area of the State.

Strong, sustained winds occur quite often in Utah causing considerable damage. In particular, the area near Beryl Junction frequently experiences high winds which contributes to a significant dust problem (Wiley, 1980). Table 3.6-3 details the reported occurrences of high winds in and near the Beaver River R.A.

Table 3.6-1

Review of Historically Damaging Hailstorms
In and Near the

BEAVER RIVER R.A.

Location	Date	Description
Panguitch	7/21/51	Heavy thunderstorms with moderate hail damaged bridges and irrigation canal.
Kanosh, Millard County	6/24/52	A severe hailstorm, lasting 10 minutes, caused heavy damage locally to gardens, fruits and some fields.
Tropic and Bryce Canyon National Park, Garfield County	8/18/56	Cooperative observers reported heavy hailstorms.
Salt Lake and Iron Counties	4/6/57	Rain caused minor flooding of some Salt Lake City streets and basements along with local hail and high winds in Salt Lake Valley.
Sevier County	7/21/57	Hail 1/4- to 1/2-inch in diameter caused extensive damage to crops in the Central and Richfield farming areas. Losses ranged from 50 to 100 percent in some areas.
Southern portion of State	10/20-21/57	Heavy rains washed out numerous roads in southern Utah, caused flooding of homes in St. George, and produced flooding on the Buckskin and Paria Rivers. Up to 18 inches of snow in the mountains stranded many hunters, especially in the Kanab, Cedar City and St. George areas. Hail up to 1-3/4 inches in diameter at Mexican Hat caused damage to trailer houses, cars and buildings.

Table 3.6-1 (Cont'd)

Review of Historically Damaging Hailstorms
In and Near the

BEAVER RIVER R.A.

Location	Date	Description
Washington County	5/58	A rather severe hailstorm hit the county, damaging all fruit, sugar beets, alfalfa, grain and vegetable crops. The damage was estimated at $100,000.
Hurricane, LaVerkin Area, Washington County	5/12/58	Hailstones up to 1-1/4 inches in diameter covered the ground to a depth of two inches, destroying crops over 75 square miles.
Emery, Kane and Iron Counties	9/8/61	A heavy thunderstorm produced hail one inch in diameter. Local crop and glass damage resulted.
Parowan Valley	6/11/70	A heavy hailstorm with hail 3/4-inch in diameter moved from southwest Iron County to northwest through the heart of the production area of Parowan Valley. The storm stripped the leaves from alfalfa, and pushed the grain in the ground, completely destroying the crops in some areas.
Zion National Park	6/22/72	Hail tore leaves and small branches from trees and shrubs and caused some damage to crops.

Table 3.6-2

Review of Historically Damaging or Severe Dust Storms
In and Near the

BEAVER RIVER R.A.

Location	Date	Description
Iron County	4/6/57	Winds reported to 44 mph and blowing dust reduced visibility to 1 mile at Cedar City.
Western portion of State	10/19/58	Strong winds accompanying the passage of a cold front caused considerable blowing dust and widespread minor property damage. Limbs were ripped off and trees toppled, causing numerous power failures. Walls were blown over, plate glass windows broken, grounded planes damaged, and other minor incidents occurred. Strong winds hampered fire fighting efforts on at least 20 range and forest fires. Highest winds were reported at Provo where gusts over 80 mph were recorded.
Southern and western portions of State	12/12/58	Strong winds blew limbs off some trees and caused other minor property damage. Winds to 60 mph produced considerable blowing dust, locally reducing visibility to zero, thus hampering highway traffic.

Table 3.6-3

Review of Historically Damaging or Severe Winds
In and Near

BEAVER RIVER R.A.

Location	Date	Description
Utah	4/18/55	Winds up to 50 mph blew down a few small buildings on the shores of the Great Salt Lake, and blew up dust over most of the State.
Salt Lake Valley and Cedar City area, Salt Lake and Iron Counties	4/6/57	Rain caused minor flooding of some Salt Lake City streets and basements and local hail in the Salt Lake Valley. Winds reported to 44 mph reduced visibility to one mile in blowing dust at Cedar City.
Northwestern portion of State	5/11/58	Winds estimated up to 70 mph hit local areas of the northwest, causing damage to trees, powerlines, automobiles and buildings.
Western portion of State	10/19/58	Strong winds accompanying the passage of a cold front caused considerable blowing dust and widespread minor property damage. Limbs were ripped off and trees toppled, causing numerous power failures. Walls were blown over, plate glass windows broken and grounded planes damaged. Strong winds hampered fire fighters' efforts on at least 20 range and forest fires. Highest winds were reported at Provo, with gusts over 80 mph.
Southern and western parts of the State	12/12/58	Strong winds blew limbs off some trees and caused other minor property damage. Winds to 60 mph produced considerable blowing dust, locally reducing visibility to zero thus hampering highway traffic.
Western Utah	2/60	High winds over western Utah caused considerable damage to a school in Logan and brought an estimated $11,000 damage to an airplane hanger and a mobile home in Saint George.

Table 3.6-3 (Cont'd)

Review of Historically Damaging or Severe Winds
In and Near

BEAVER RIVER R.A.

Location	Date	Description
Northern and western portion of State	8/22/60	An intense cold front, accompanied by winds up to 69 mph, moved across the State causing extensive damage to power lines, buildings and trees. Blowing dust on the highways contributed to an accident in Salt Lake County in which six persons were injured. In Weber County, two boys were hurt when an uncompleted house was blown down. Four persons in Tooele County were injured in an accident due to an auto going out of control in strong winds.
Western portion of State	4/22/61	Blowing dust, as a result of strong winds, contributed to a six-car crash near Loa, in Tooele County. Wind gusts, which were reported as high as 69 mph, damaged utility poles, fences, billboards, trees and homes in western Utah.
Northwest portion of State	1/20-1/21/62	Strong winds snapped power lines and poles, blew down walls and trees, and drifting snow blocking highways.
Milford	8/19/66	Gusty winds up to 70 mph, associated with thunderstorms, hit Milford Airport during the afternoon. The winds blew a roof off the hanger and carried it onto the highway sheering off several power and telephone poles. Three light planes were destroyed. Estimated damage exceeded $20,000.
Milford, Beaver County	12/5/66	A severe wind storm of over 58 miles per hour struck Milford airport, damaging a trailer, blowing down a cinder block wall, and wrecking an office. Power lines were cut leaving the weather station without power for six hours.

Table 3.6-3 (Cont'd)

Review of Historically Damaging or Severe Winds
In and Near

BEAVER RIVER R.A.

Location	Date	Description
Western Utah	4/5/67	Winds, 60 to 75 mph, slashed western Utah during the early morning hours and produced an estimated $100,000 damage to homes, barns, trees, shrubs, walls, etc. In Cedar City a telephone booth was smashed and dust was several inches thick in some places. Two planes were blown over and seriously damaged in Provo. Several hundred feet of a theater wall was blown down in Orem. Roofs were blown off buildings; hay and barns destroyed and trees blown across power lines and automobiles in Cache County. Highest winds were recorded at Dugway, 93 miles per hour.
Western Utah	4/15/67	The second damaging windstorm within two weeks in western Utah struck during the afternoon and evening of April 15. Winds again ripped off roofs and blew down walls and trees over many sections of western Utah County. Winds also blew over a 65 foot ferris wheel causing over $10,000 damage.
San Juan, Wayne, Emery, Garfield and Kane Counties	12/20-21/67	A series of snow storms brought snow to record December depths in many sections of southeastern Utah. Strong easterly winds on the 20th and 21st caused heavy drifting which closed most roads in the area and isolated outlying homes and ranches with snow drifts to over 10 feet. Indians in southeastern San Juan suffered hunger and exposure and three deaths from exposure were reported. 8,000 to 10,000 cattle and several thousand sheep were isolated, but reports of losses were not available.

Table 3.6-3 (Cont'd)

Review of Historically Damaging or Severe Winds
In and Near

BEAVER RIVER R.A.

Location	Date	Description
Northwest portion of the State	1/21-29/69	This was one of the windiest January periods in the history of the State. Damaging winds were reported on the 21, 22, 23, 28 and 29, but strong winds were reported throughout most of the period. On the 21st, gusts to 100 mph were reported at Stansbury and damage to homes in Centerville was reported. On the 22nd, winds damaged buildings and signs in northern Davis County and southern Weber County exceeding $5,000. On the 26th, winds in excess of 100 miles per hour were reported by the Treasure Mountain Ski Resort with damage to homes and vegetation along the Wasatch Front. On the 29th, blizzard conditions developed at the Point of the Mountain with near zero visibility.
Northwestern Counties	8/69	A series of thunderstorms accompanied by winds up to 70 miles an hour swept across northwestern Utah during the evening toppling trees onto automobiles and homes, breaking windows and power lines.
Western portion of State	4/14/70	Winds, clocked at between 55 and 60 miles per hour and gusts over 75 mph, whipped up dust which limited visibility and was a contributing factor in two multi-car collisions.
Western portion of State	4/27/70	A major spring snow storm, preceded by strong southerly winds, swept across much of western Utah. Heavy cross winds veered an automobile into a steel and concrete abutment north of St. George killing the driver and seriously injuring his passenger. In southern Salt Lake City, wind and snow were blamed for another fatal accident where two cars met head-on killing the driver of one and injuring the occupants of the other. The heavy snow, one of the worst snowstorms ever to occur so late in the year, left motorists stranded and caused many minor accidents.

Table 3.6-3 (Cont'd)

Review of Historically Damaging or Severe Winds In and Near

BEAVER RIVER R.A.

Location	Date	Description
North and central portions western Utah	6/27/70	Winds with gusts up to 80 miles per hour began near Milford and of moved northward into the northwestern part of the State causing damage over much of the area. Power and telephone lines were damaged by tree limbs. Roofs were ripped off several homes, one of which landed on top of a moving automobile in the Provo area injuring the driver. Bricks and limbs broke windows in many areas and blowing dust near Mills Junction was the major cause of a five-car pile up which injured 12 people.
Cache, Box Elder, Weber, Davis, Salt Lake, Utah and Iron Counties	10/23/73	Strong gusty winds, associated with locally heavy rainshowers, accompanied a cold frontal passage through western Utah during the afternoon hours. Numerous power outages were reported, as power lines and trees snapped. Wind gusts in excess of 50 miles per hour were reported at Cedar City. Locally heavy rainfall and heavy snowfall over higher mountain summits caused numerous accidents.
Iron County	11/12/73	A vicious wind storm accompanied by a strong cold frontal passage moved through northern and western Utah during the late morning and afternoon hours. Strong gusty southerly winds increased and then shifted to the northwest with peak gusts in the Salt Lake, Ogden and Tooele areas averaging between 70 and 75 mph. Damage to mobile homes, roofs, outdoor signs, and buildings under construction was estimated at about $200,000. Many trees were uprooted and power lines were blown down to account for thousands of reported power outages throughout northern Utah which lasted most of the night.

4. PREVAILING WINDS

The characterization of prevailing surface winds is essential in the development of an understanding of the climate of a region. This section provides analyses that are designed to identify specific characteristics of the prevailing winds. These analyses include:

- Wind Roses
- Wind Speed Distributions
- Wind Persistence Analyses

The prevailing winds define the net regional transport characteristics for pollutants in a given geographical area. An understanding of the physical behavior of air flow in and out of a particular area of interest provides insight as to the fate of air pollutants, and therefore, may affect decisions as to the siting of industrial sources.

Wind patterns are often the result of topographic influences as indicated in Section 3.1.3. Thus, data presented in this section can only be extrapolated to areas with differing terrain features with extreme caution.

4.1 WIND ROSES

Wind roses provide a graphical representation of the frequency of occurrence of winds from each of the 16 cardinal directions for specified averaging periods. This subsection discusses the prevailing winds using wind rose analyses on a seasonal and annual basis. The discussion provided is designed to summarize prevailing air flow characteristics in terms of a dispersion analyses for subsequent use in pollutant impact studies. Wind data are available at two stations in this R.A. These include Milford (7/48 to 12/78) and Cedar City (11/48 to 12/78).

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Wind roses provide a graphical representation of the frequency of occurrence of winds from each of the 16 cardinal directions for specified averaging periods. This subsection discusses the prevailing winds using wind rose analyses on a seasonal and annual basis. The discussion provided is designed to summarize prevailing air flow characteristics in terms of a dispersion analysis for subsequent use in pollutant impact studies. Wind data are available at two stations in this R.A. These include Milford (1/48 to 12/78) and Cedar City (11/48 to 12/78).

Seasonal and annual wind rose diagrams for Milford and Cedar City are provided in Figures 4.1-1 through 4.1-12. Diurnal wind roses have also been provided for Cedar City, a station which is strongly influenced by nearby topography and thus exhibits a marked change in wind flow. Roses are delineated into day (one-half after sunrise to one-half hour before sunset) and night. All wind rose diagrams employ a telescopic technique to display not only the frequency of wind directions (indicated by the percentage on each circle, increasing with didstance from the center), but also the frequency of occurrence of each wind speed class in conjunction with the wind direction (indicated by blocked areas on telescope and key at upper right corner of figure, such that the length of the first block from the center always indicates the percent frequency of winds from 1 to 3 knots in a given wind direction). The zero line has been displaced from the center and may be implied by the start of each "telescope".

The annual and seasonal wind roses for Milford show a bimodal distribution of wind direction with a preference for winds from the south through southwest and a secondary maximum for flow from the north through north-northeast. This southerly dominance represents channeling of the prevailing westerly flow through the Escalante Desert and turning north through the Beaver River Valley. These account for almost 50 percent of the distribution on an annual basis. Wind speeds associated with south through southwest winds are quite strong, with winds in the fourth, fifth and sixth wind speed classes (11 to greater than 21 knots) occurring about 57 percent with these directions. The northerly and north-northeasterly flow represents upslope flow which develops in the late morning and mid-afternoon with the onset of strong surface heating. The frequency of wind directions other than these stated is quite minimal. Calms occur at this location only 7 percent of the time.

Wind roses for Cedar City are provided in Figures 4.1-6 through 4.1-12. The annual rose shows a distinct preference for winds from the south-west and south-southwest. These directions, which account for about 24 percent of the distribution, represent channeling of flow through the Ash Creek

Seasonal and annual wind rose diagrams for Milford and Cedar City are provided in Figures A.1-1 through A.1-12. Diurnal wind roses have also been provided for Cedar City, a station which is strongly influenced by nearby topography and thus exhibits a marked change in wind flow. These are catagorized into day (one-half after sunrise to one-half hour before sunset) and night. All wind rose diagrams employ a telescopic technique to display not only the frequency of wind directions (indicated by the percentage on each circle, increasing with diastance from the center), but also the frequency of occurrence of each wind speed class in conjunction with the wind direction (indicated by blocked areas on telescope and key at upper right corner of figure, such that the length of the first block from the center always indicates the percent frequency of winds from 1 to 3 knots in a given wind direction). The zero line has been displaced from the center and may be applied at the start of each "telescope".

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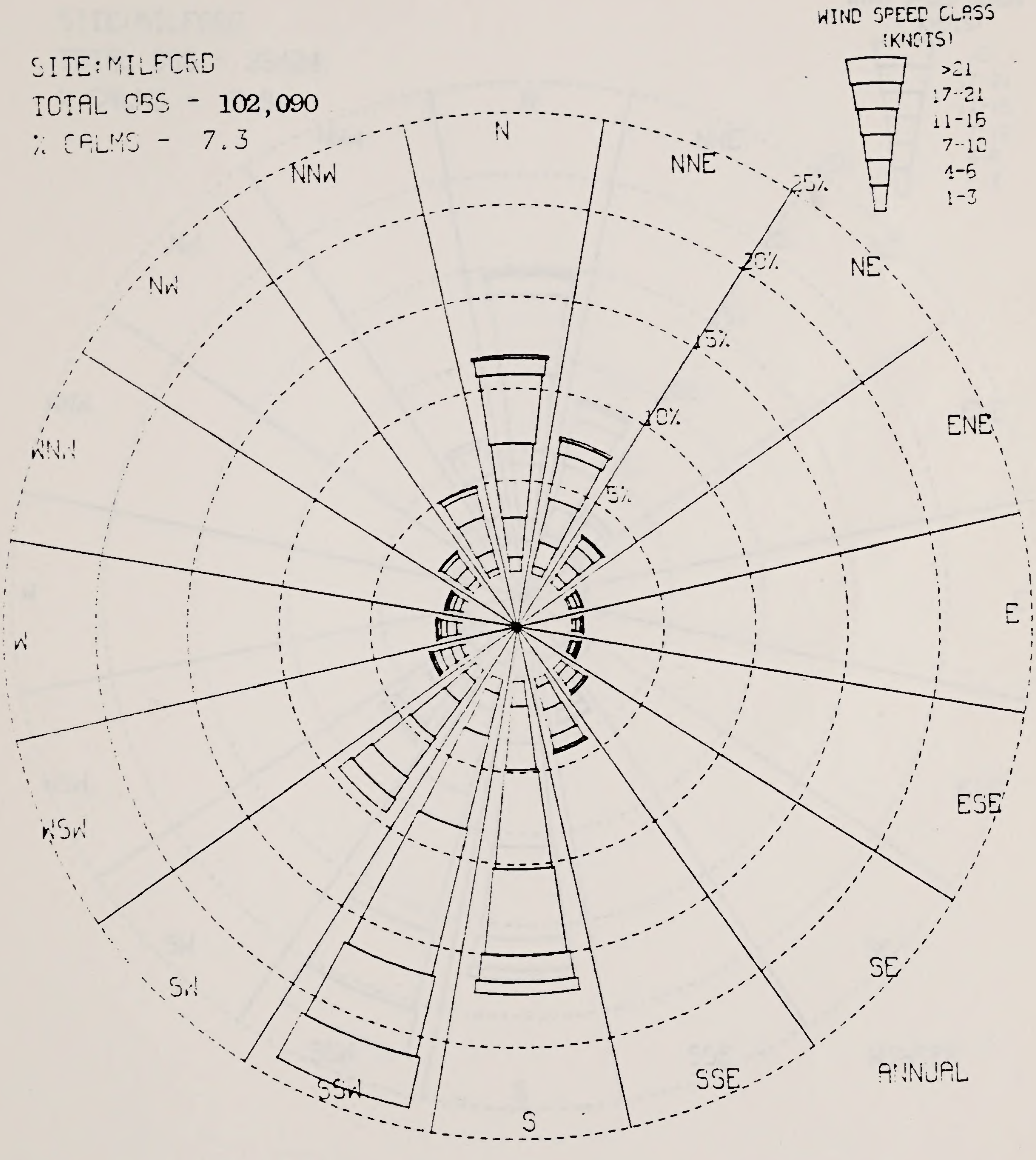

Figure 4.1-1
Annual Wind Rose for Milford
(7/48 - 12/78)

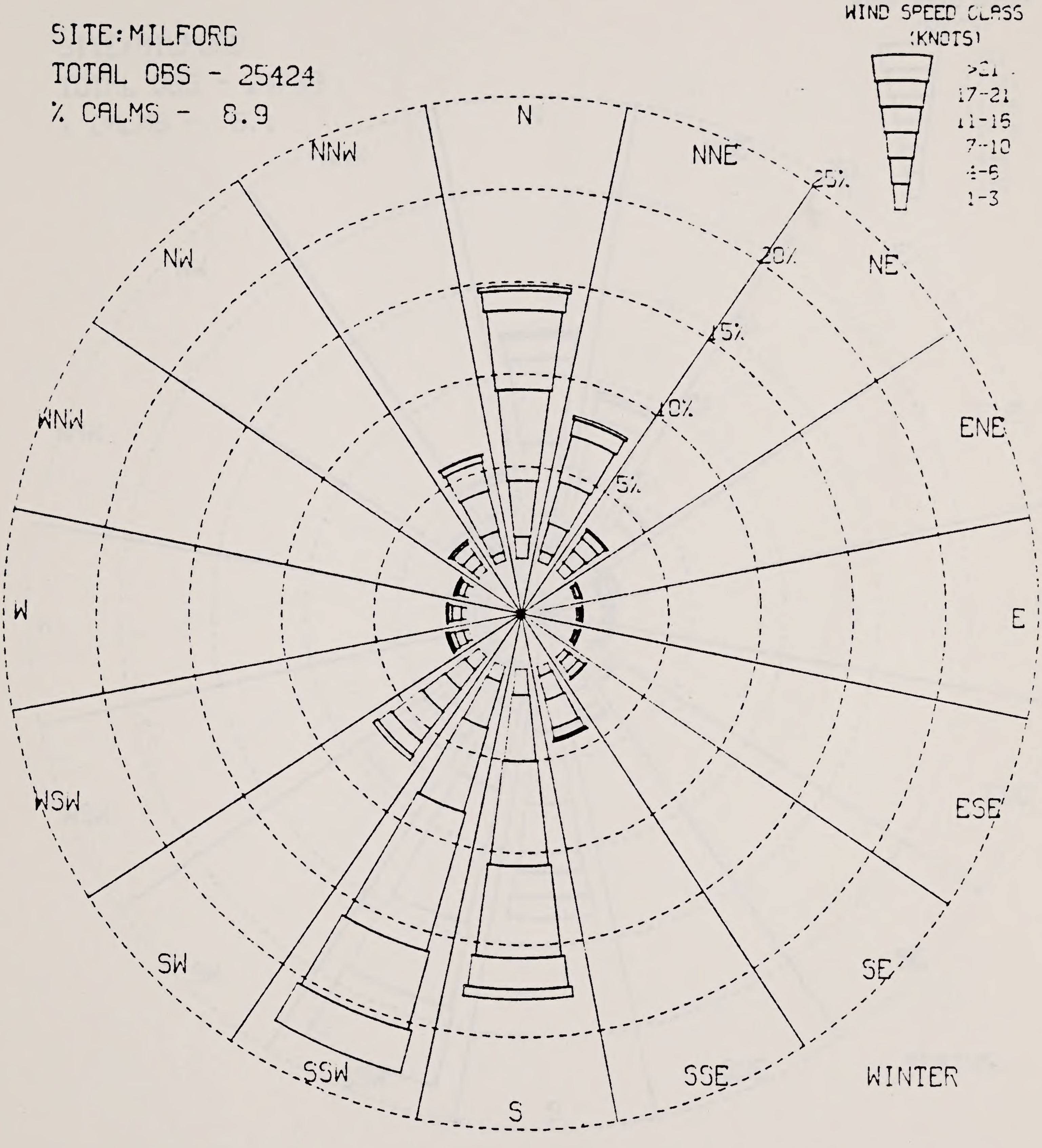

Figure 4.1-2

Winter Wind Rose for Milford

(7/48 - 12/78)

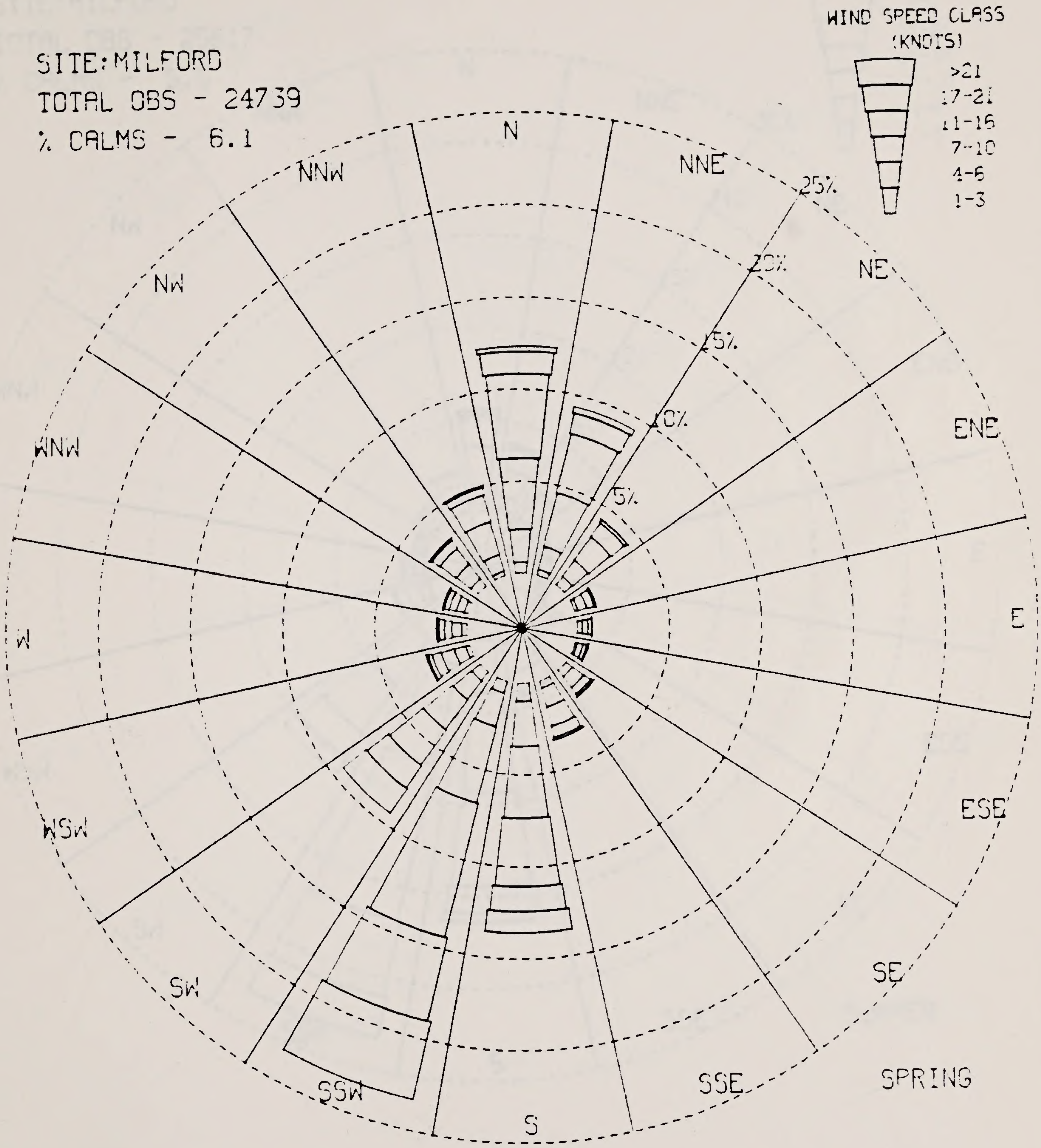

Figure 4.1-3
Spring Wind Rose for Milford
(7/48 - 12/78)

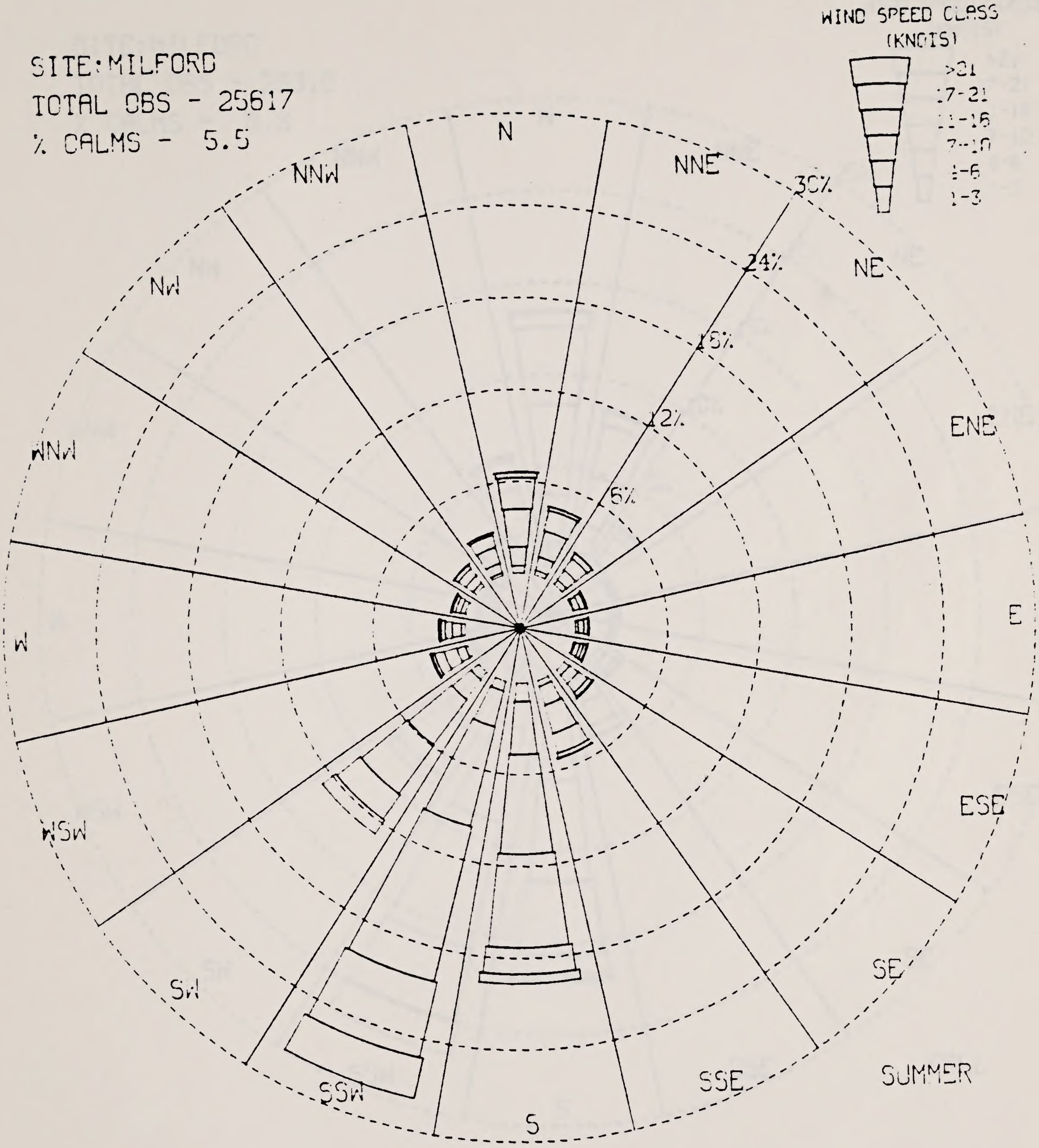

Figure 4.1-4
Summer Wind Rose for Milford
(7/48 - 12/78)

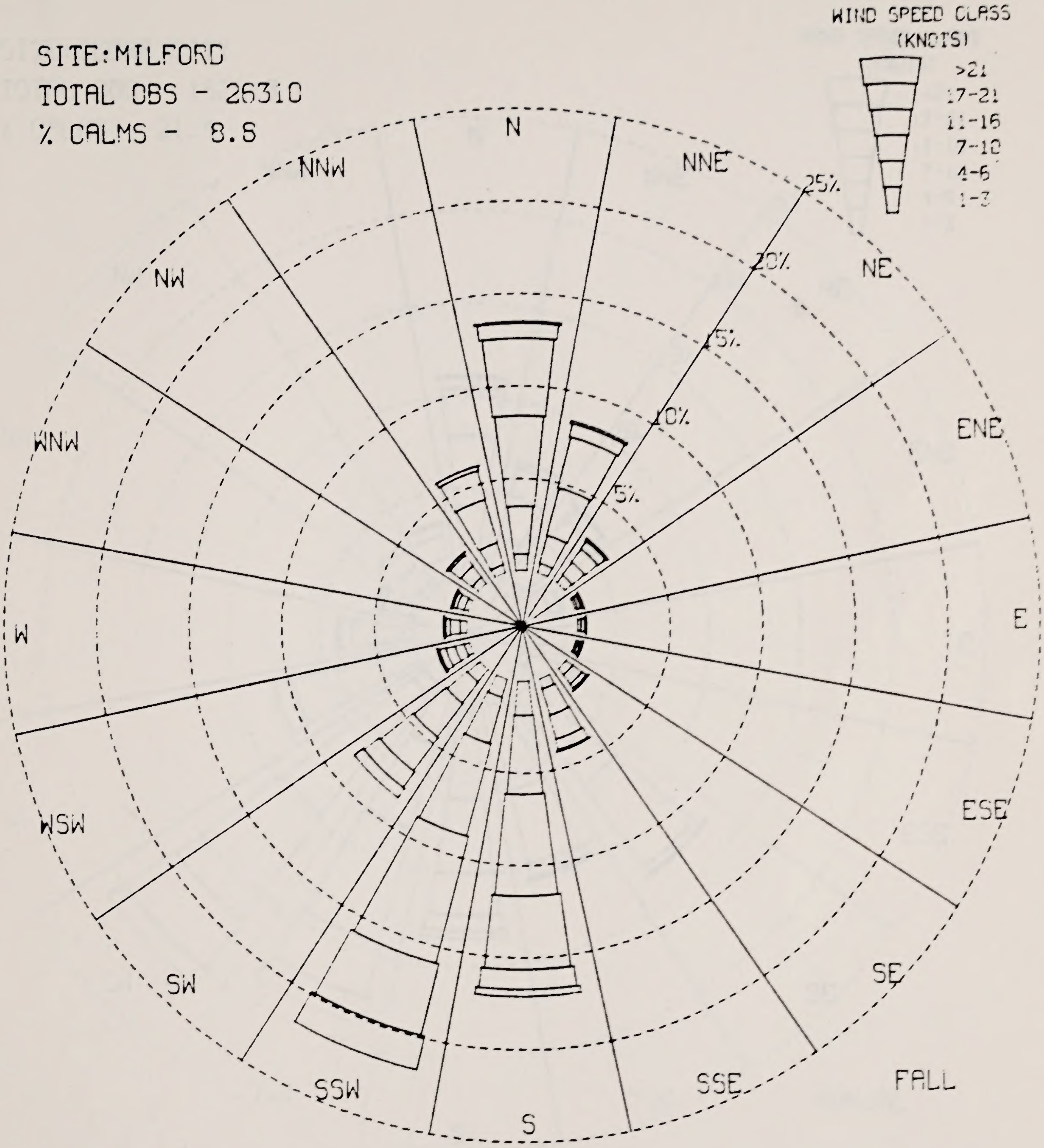

Figure 4.1-5
Fall Wind Rose for Milford
(7/48 - 12/78)

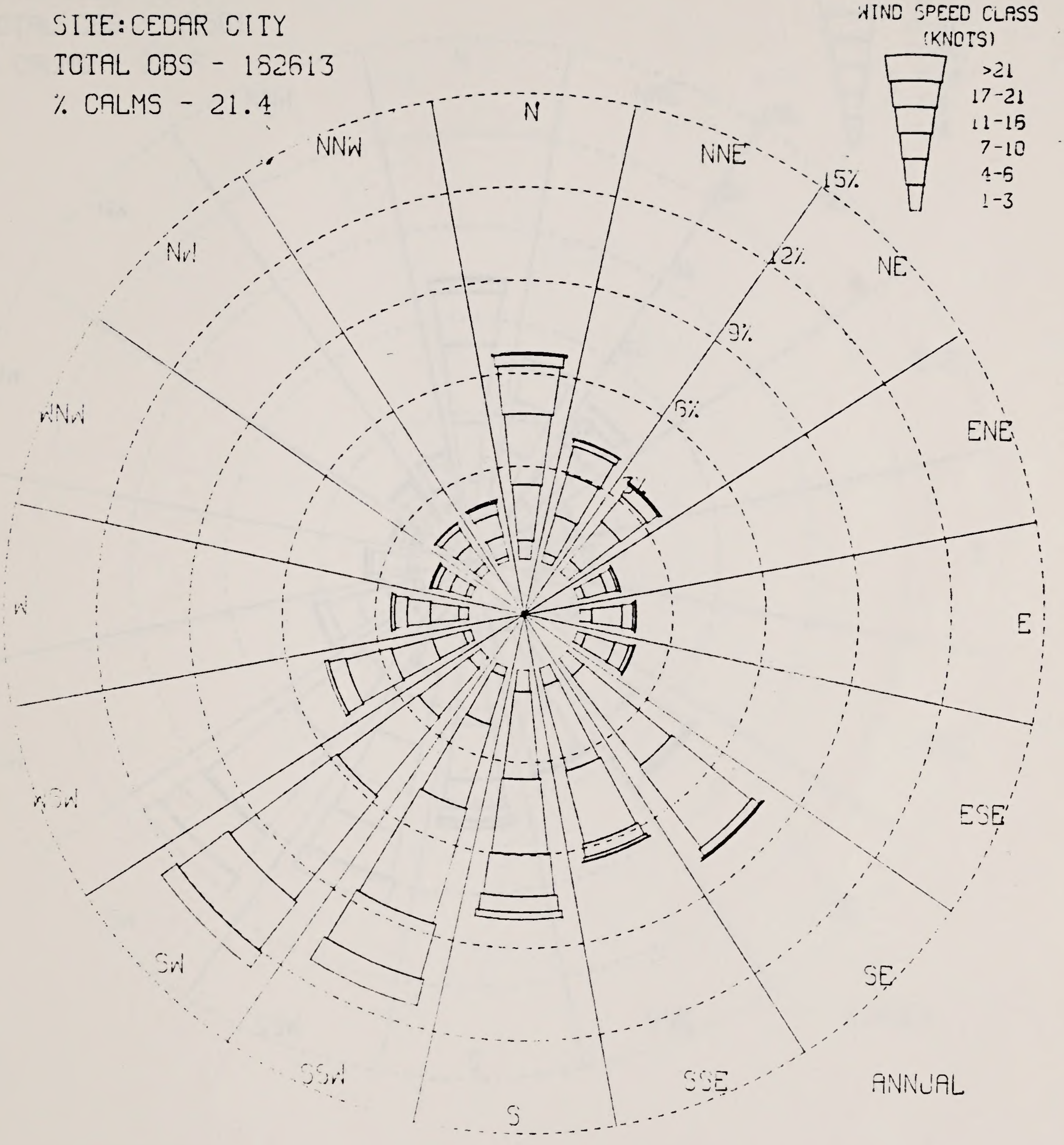

Figure 4.1-6
Annual Wind Rose for Cedar City
(11/48-12/78)

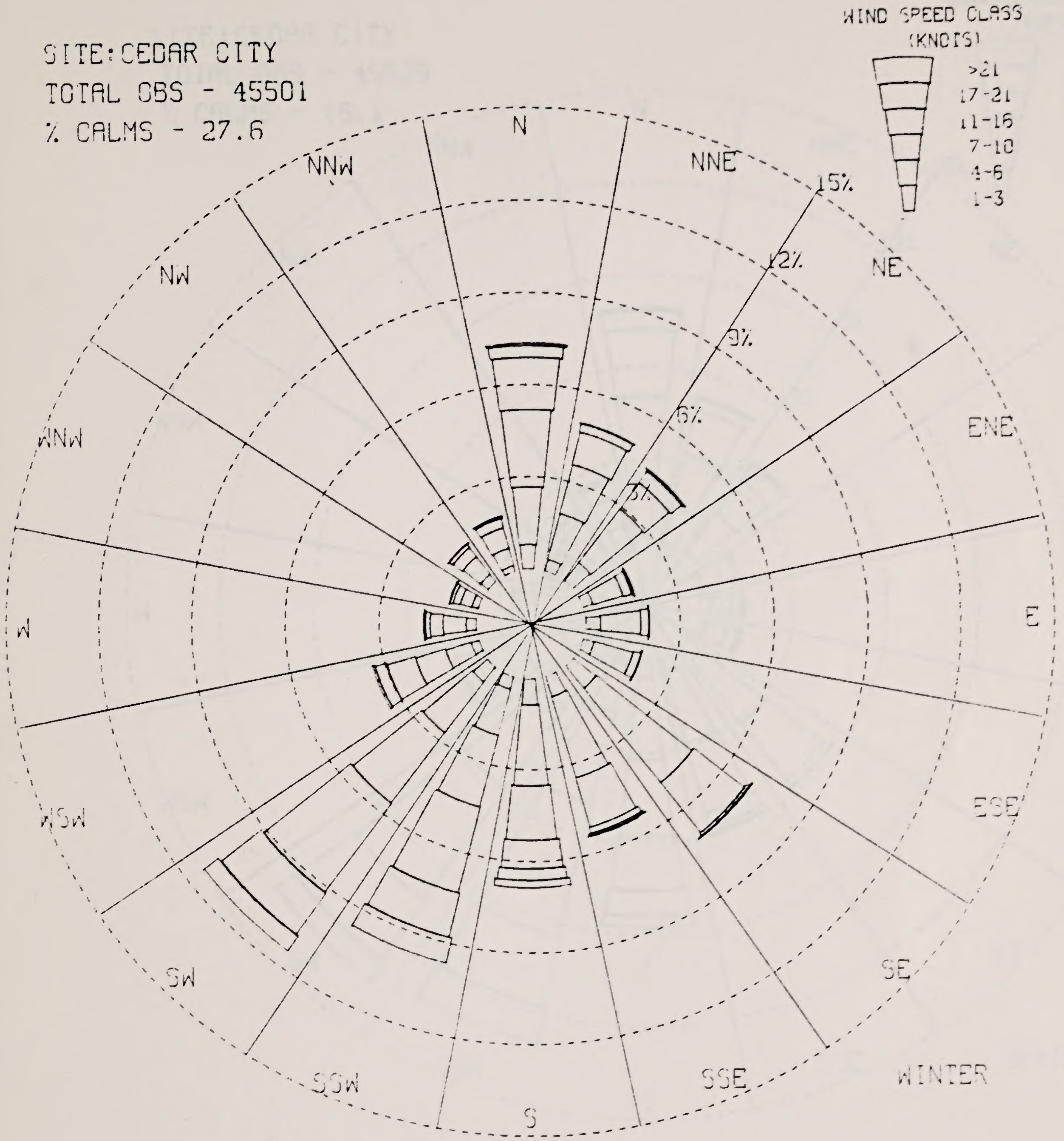

Figure 4.1-7
Winter Wind Rose for Cedar City
(11/48-12/78)

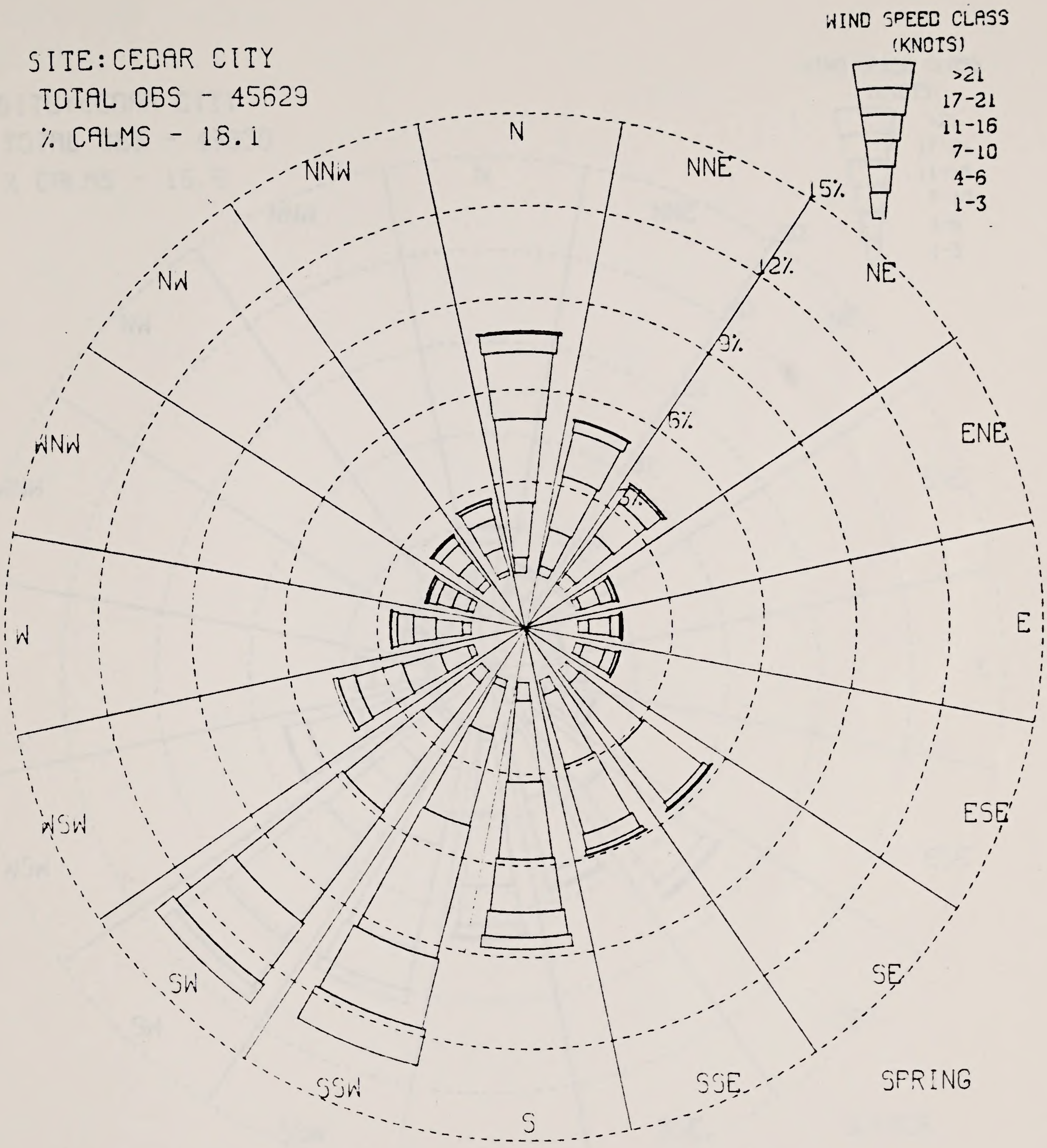

Figure 4.1-8
Spring Wind Rose for Cedar City
(11/48-12/78)

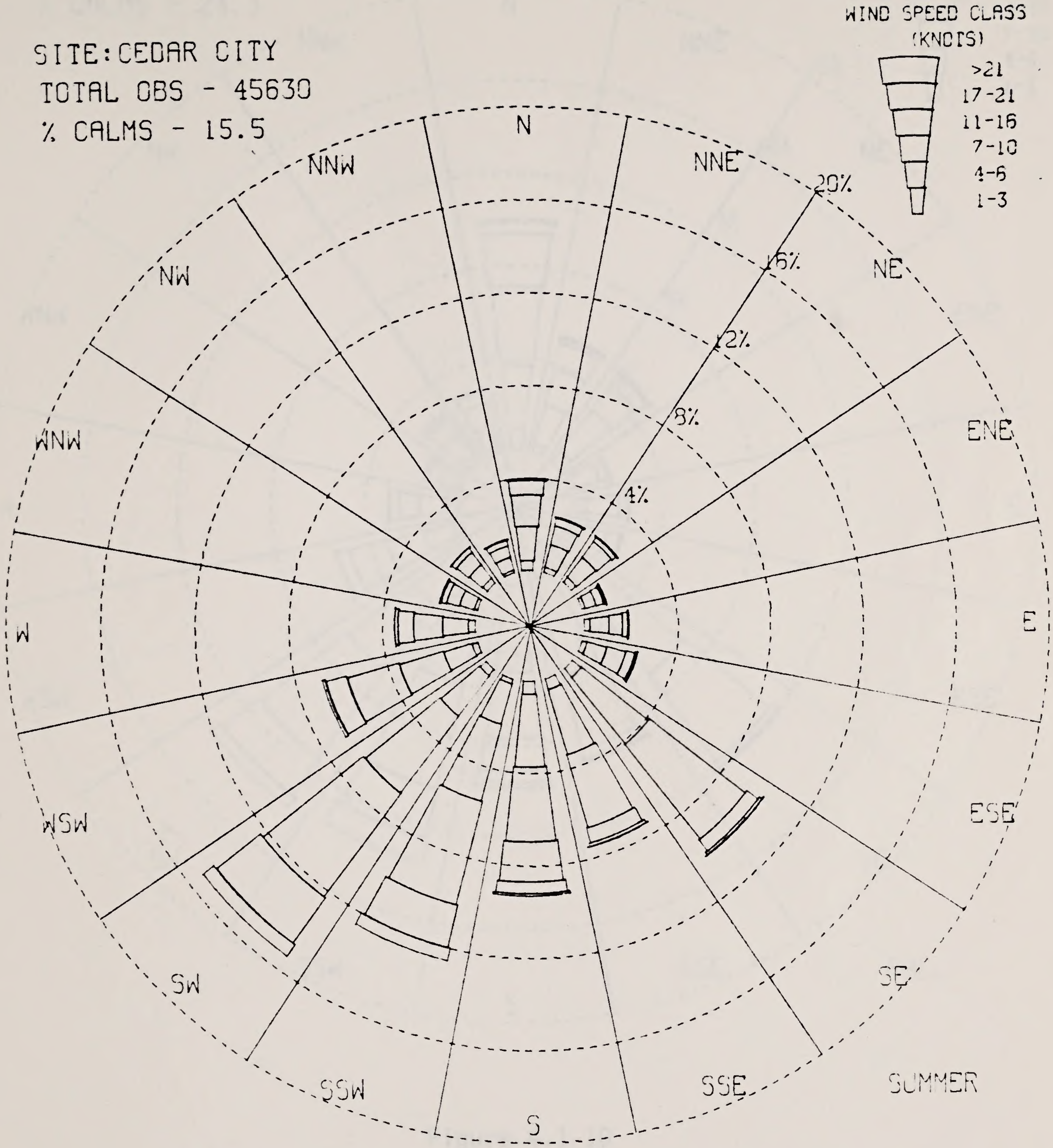

Figure 4.1-9
Summer Wind Rose for Cedar City
(11/48-12/78)

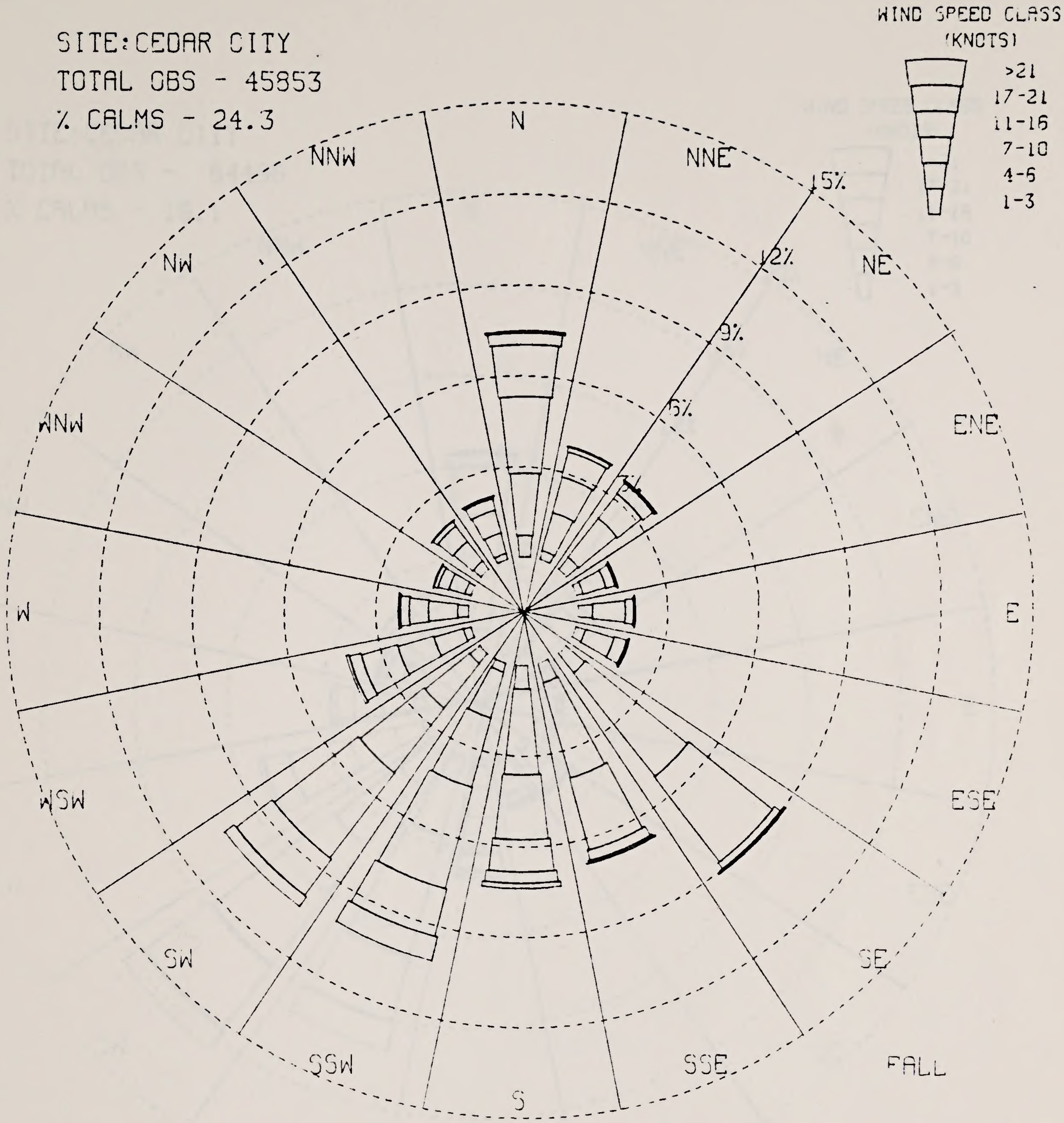

Figure 4.1-10
Fall Wind Rose for Cedar City
(11/48-12/78)

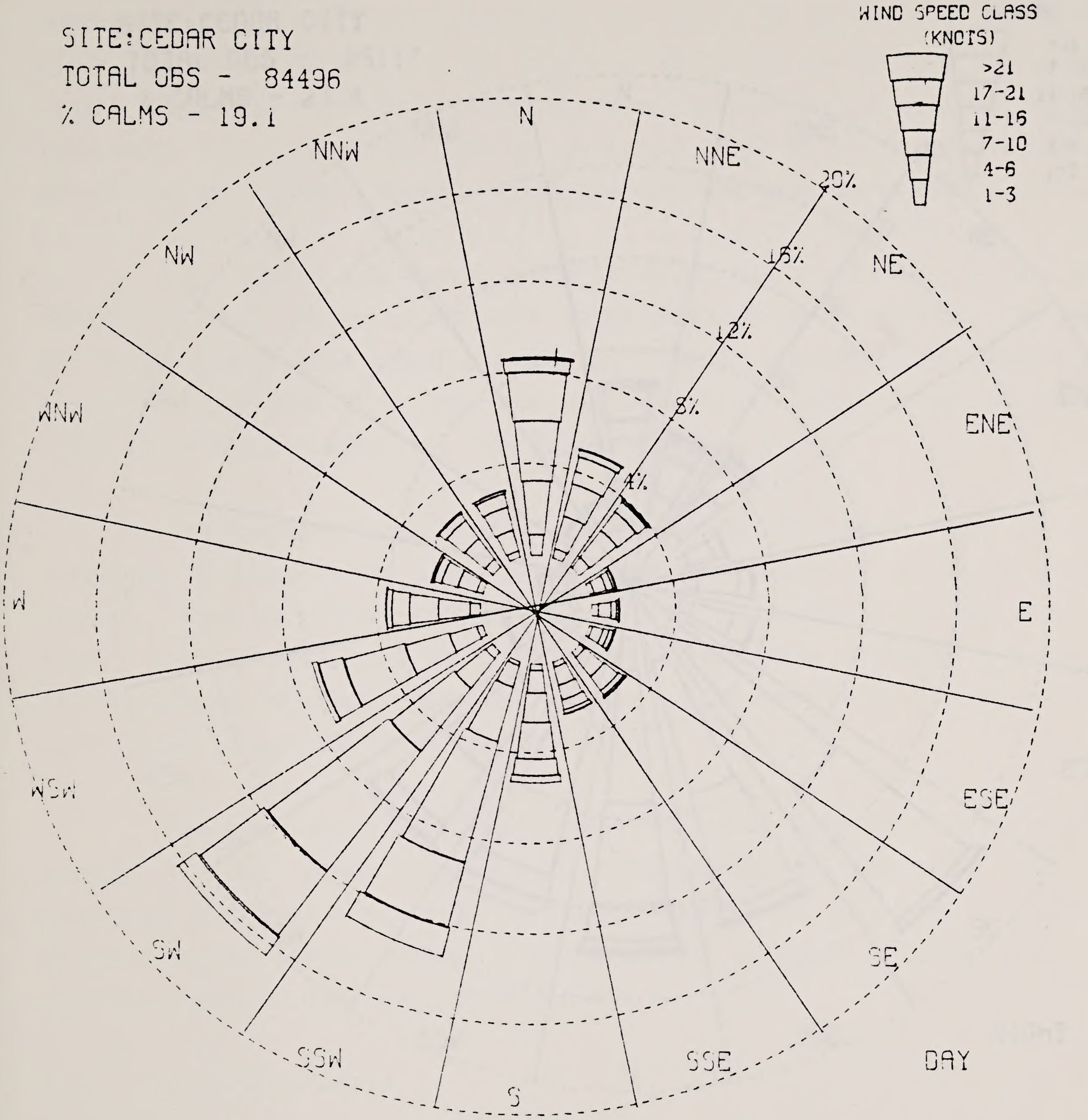

Figure 4.1-11
Day Annual Wind Rose for Cedar City
(11/48-12/78)

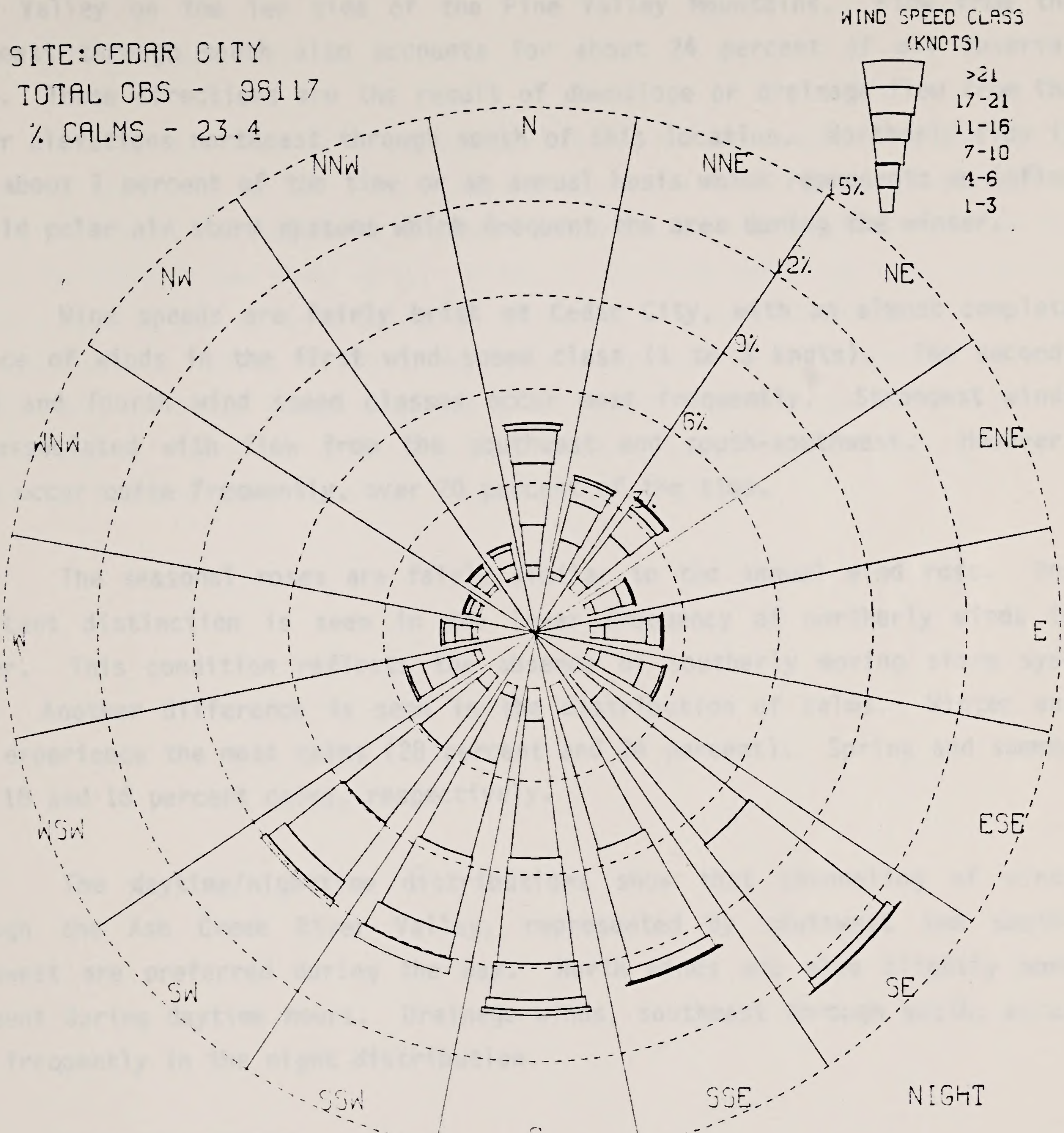

Figure 4.1-12
Night Annual Wind Rose for Cedar City
(11/48-12/78)

River Valley on the lee side of the Pine Valley Mountains. Flow from the southeast through south also accounts for about 24 percent of all observations. These directions are the result of downslope or drainage flow from the higher elevations northeast through south of this location. Northerly flow is seen about 7 percent of the time or an annual basis which represents an influx of cold polar air storm systems which frequent the area during the winter.

Wind speeds are fairly brisk at Cedar City, with an almost complete absence of winds in the first wind speed class (1 to 3 knots). The second, third and fourth wind speed classes occur most frequently. Strongest winds are associated with flow from the southwest and south-southwest. However, calms occur quite frequently, over 20 percent of the time.

The seasonal roses are fairly similar to the annual wind rose. One important distinction is seen in the lower frequency of northerly winds in summer. This condition reflects the absence of southerly moving storm systems. Another difference is seen in the distribution of calms. Winter and fall experience the most calms (28 percent and 24 percent). Spring and summer have 18 and 16 percent calms, respectively.

The daytime/nighttime distributions show that channeling of winds through the Ash Creek River Valley, represented by southwest and south-southwest are preferred during the day. North winds are also slightly more frequent during daytime hours. Drainage winds, southeast through south, occur more frequently in the night distribution.

4.2 PEAK WIND SPEEDS

Strong, sustained winds occur quite often in Utah, sometimes causing considerable damage. Historical occurrences of severe winds in the Beaver River R.A. have been described in Table 3.6-3. The highest wind speed at Milford was 52.9 mph during the period July, 1948 through December, 1978. The highest speed at Cedar City during the period November, 1948 to December 1978 was 55.2 mph.

4.3 PERSISTENCE ANALYSES

The persistence of wind speed classes is important in defining the dispersion potential of an area. Tables 4.3-1 and 4.3-2 provide persistence data for winds in the following classes: 0-9 mph, 10-19 mph, 20-29 mph and 40-98 mph for Milford and Cedar City. Winds in the 0-19 mph range have persisted for more than a day at both of these locations. Speeds of 20 to 98 mph are less persistent. Winds of 20-30 mph have persisted for 16 hours at Milford and 21 hours at Cedar City; winds of 30-39 mph have persisted for 9 hours at Milford and 13 hours at Cedar City and winds greater than 40 mph have persisted for 8 hours at Milford and 7 hours at Cedar City.

Table 4.3-1

Persistence of Wind Speed Categories (%) at Cedar City

(1 Hour Intervals/Miles per Hour)

(11/48 - 12/78)

INTERVALS	0-9	10-19	20-29	30-39	40-98
1 OR MORE	57.99	26.90	7.42	0.57	0.08
2 OR MORE	41.45	17.07	4.55	0.34	0.05
3 OR MORE	39.92	13.75	3.51	0.23	0.04
4 OR MORE	38.46	10.86	2.72	0.14	0.03
5 OR MORE	37.18	8.41	2.10	0.10	0.02
6 OR MORE	35.82	6.51	1.57	0.07	0.01
7 OR MORE	34.51	4.92	1.20	0.04	0.01
8 OR MORE	33.33	3.72	0.85	0.02	0.00
9 OR MORE	31.96	2.72	0.58	0.02	0.00
10 OR MORE	30.64	1.96	0.36	0.01	0.00
11 OR MORE	29.16	1.41	0.28	0.01	0.00
12 OR MORE	27.48	1.03	0.17	0.01	0.00
13 OR MORE	25.71	0.75	0.11	0.01	0.00
14 OR MORE	23.73	0.57	0.08	0.00	0.00
15 OR MORE	21.78	0.41	0.05	0.00	0.00
16 OR MORE	19.76	0.27	0.04	0.00	0.00
17 OR MORE	17.80	0.20	0.01	0.00	0.00
18 OR MORE	15.55	0.15	0.01	0.00	0.00
19 OR MORE	13.84	0.15	0.01	0.00	0.00
20 OR MORE	12.28	0.13	0.01	0.00	0.00
21 OR MORE	10.82	0.10	0.01	0.00	0.00
22 OR MORE	9.61	0.06	0.00	0.00	0.00
23 OR MORE	8.59	0.03	0.00	0.00	0.00
24 OR MORE	7.96	0.01	0.00	0.00	0.00
25 OR MORE	7.43	0.01	0.00	0.00	0.00

TOTAL OBSERVATIONS = 182613

MAXIMUM WIND SPEED = 55.2

Table 4.3-2

Persistence of Wind Speed Categories (%) at Milford

(1 Hour Intervals/Miles per Hour)

(7/48 - 12/78)

INTERVALS	0-9	10-19	20-29	30-39	40-98
1 OR MORE	43.02	40.66	13.06	1.58	0.17
2 OR MORE	33.24	29.07	8.84	0.94	0.09
3 OR MORE	30.02	24.15	6.99	0.68	0.06
4 OR MORE	26.75	19.68	5.51	0.52	0.05
5 OR MORE	23.90	15.52	4.33	0.34	0.04
6 OR MORE	21.49	12.02	3.20	0.20	0.03
7 OR MORE	19.22	9.06	2.24	0.13	0.02
8 OR MORE	17.49	6.71	1.45	0.08	0.02
9 OR MORE	14.67	4.00	0.72	0.04	0.00
10 OR MORE	13.41	2.98	0.43	0.00	0.00
11 OR MORE	12.50	2.33	0.24	0.00	0.00
12 OR MORE	11.55	1.87	0.12	0.00	0.00
13 OR MORE	10.82	1.38	0.10	0.00	0.00
14 OR MORE	9.97	0.98	0.05	0.00	0.00
15 OR MORE	9.35	0.82	0.05	0.00	0.00
16 OR MORE	8.78	0.54	0.03	0.00	0.00
17 OR MORE	5.96	0.35	0.00	0.00	0.00
18 OR MORE	5.32	0.27	0.00	0.00	0.00
19 OR MORE	4.76	0.25	0.00	0.00	0.00
20 OR MORE	4.26	0.17	0.00	0.00	0.00
21 OR MORE	3.85	0.14	0.00	0.00	0.00
22 OR MORE	3.45	0.07	0.00	0.00	0.00
23 OR MORE	3.07	0.07	0.00	0.00	0.00
24 OR MORE	2.68	0.07	0.00	0.00	0.00
25 OR MORE	2.45	0.07	0.00	0.00	0.00

TOTAL OBSERVATIONS = 102093

MAXIMUM WIND SPEED = 52.9

less persistent. Winds of 20-30 mph have persisted for 16 hours at Milford and 21 hours at Cedar City; winds of 30-39 mph have persisted for 9 hours at Milford and 13 hours at Cedar City and winds greater than 40 mph have persisted for 8 hours at Milford and 7 hours at Cedar City.

5. GLOSSARY OF TERMS

Abscissa	The Horizontal coordinate or axis of any graph; usually denoted by X.
Absorption	The process in which incident radiant energy is retained by a substance.
Advection	The process of transport of an atmospheric property solely by the mass motion (i.e., wind) of the atmosphere.
Aitken Nuclei	The microscopic particles in the atmosphere which serve as condensation nuclei for droplet growth. These nuclei are both liquid and solid with diameters of tens of microns or smaller.
Albedo	A measure of the part of the incoming solar radiation which is reflected from the earth and the atmosphere.
Annual Moisture Deficit	The moisture deficit of a month is the potential evapotranspiration less the rainfall and stored soil water. The sum of the appropriate months is the annual moisture deficit.
Anticyclone	Movements of air traveling in a clockwise direction (in the northern Hemisphere). Since anticyclone circulation and relative high atmospheric pressure usually coexist, the terms anticyclone and high pressure are often used interchangeably.
Attentuation	The process by which energy decreases with increasing distance from the energy source
Ceiling	The height of the lowest layer of clouds or other obscuring phenomena (e.g., dust). During clear weather, the ceiling in unlimited. With fog, the ceiling is obscured.
Centripetal Acceleration	Acceleration on a particle moving in a curved path, directed toward the center of curvature of the path.
Climate	The average condition of the weather at a place over a period of years as exhibited by temperature, wind velocity, precipitation and related parameters.
Compressional Heating	The disturbance of a fluid (e.g., air) such that the pressure and density and, therefore temperature, increase in the direction of motion.
Condensation	The physical process by which a vapor becomes a liquid or a solid.

Condensation Nuclei	A particle, either liquid or solid, upon which condensation of water vapor begins in the atmosphere.
Continental Climate	The climate that is characteristic of the interior of a land mass. It is marked by large annual, daily and day to day ranges of temperature, humidity and precipitation.
Convection	In general, mass motions within a fluid (e.g., air) resulting in transport and mixing of the properties of that fluid.
Coriolis Force	A deflective force resulting from the earth's rotation; it acts to the right of wind direction in the Northern Hemisphere and to the left in the Southern Hemisphere.
Crystallization	The process which results in the formation of ice crystals in the atmosphere.
Cumulonimbus	A principal cloud type, exceptionally dense and vertically developed, occurring either as isolated clouds or as a line or wall of clouds with separated upper portions.
Cumulus	A principal cloud type in the form of individual, detached elements which are generally dense and possess sharp non-fibrous outlines.
Cyclones	Movements of air traveling in a counterclockwise direction (in the northern Hemisphere). Since cyclonic circulation and relative low atmospheric pressure usually coexist, the terms clclone and low pressure system often are used interchangeably.
Cyclonic Storms	Large storm systems (50 to 900 miles in diameter or more) characterized by air rotating around a center of low pressure. More common in winter than summer. Rainfall and snowfall associated with such storms may be light, but may persist for two to three days or longer.
Dew Point	The temperature to which air must be cooled in order for saturation to occur.
Dew Point Depression	The difference between the air temperature and the dew point.
Divergence	The expansion or spreading out of a vector field (e.g., velocity field).
Drainage Wind	A wind directed down the slope of an incline and caused by greater air density near the slope than at the same level some distance horizontally from the slope.

Dry Bulb Temperature The ambient temperature of the air as measured by a dry-bulb thermometer.

Eddy Viscosity The turbulent transfer of momentum by eddies (a glob of fluid with a fluid mass that has a life history of its own) giving rise to fluid friction.

Electromagnetic The ordered array of all known electromagneti Spectrum radiations, extending from the shortest cosmic rays, through gamma rays, x-rays, ultraviolet light, visible/light, infrared radiation, and including microwave and all other lengths of radio energy.

Electromagnetic Waves Energy propagated through space or through material media in the form of an advancing disturbance in electric and magnetic fields existing in space.

Evaporation The physical process that returns water from the earth to the atmosphere.

Evapotranspiration The combined processes by which water is transferred from the surface of the earth to the atmosphere; evaporation of liquid or solid water plus transpiration from plants.

Exposure The general surroundings of a site, with special reference to its openness to winds and sunshine.

Fall Velocity That velocity attained by a body freely falling in air when the resisting force is equal to the gravitational force.

First Order Stations A meteorological station at which automatic records and hourly readings of weather elements are made.

Free Atmosphere That portion of the earth's atmosphere, above the planetary boundary layer, in which the effects of the earths surface friction on the air motion are negligible.

Friction Layer The term is interchangeable with planetary boundary layer and surface boundary layer and refers to the layer between the surface and the free atmosphere.

Frictional Drag The frictional impedence offered by air to the motion of bodies passing through it.

Front In meteorology, generally, the interface or transition zone between two air masses of different density.

Frost-Free Period The frost-free period refers to the length of the growing season as determined by the number of days between the last frost (i.e., 32°F) in spring and the first frost in fall.

Gradient	The rate of change of a parameter as a function of distance.
Greenhouse Effect	The heating effect exerted by the atmosphere upon the earth by virtue of the fact that the atmosphere absorbs and re-emits infrared radiation.
Growing Season	Generally, the period of the year during which the temperature of cultivated vegetation remains sufficiently high to allow plant growth (Usually synonymous with Frost-Free Period).
Hygroscopic Nuclei	Nuclei with a marked ability to accelerate the condensation of water vapor.
Infrared (Radiation)	Electromagnetic radiation lying in the wave length interval between visible radiation (light) and microwave radiation.
Inversion	A departure from the usual decrease or increase with altitude of the value of an atmospheric property (almost always of temperature). In a temperature inversion, temperature increases with altitude. A temperature inversion is stable, allowing little turbulent exchange to occur.
Inversion Layer	That layer of air which departs from the usual decrease in temperature with increasing altitude.
Ions	In atmospheric electricity, any of several types of electrically charged submicroscopic particles normally found in the atmosphere.
Isobars	A line of equal or constant pressure.
Isohyet	A line drawn through geographical points recording equal amounts of precipitation during a given time period or for a particular storm.
Isopluvial	Line drawn through geographic points having the same precipitation amount likely to be equalled or exceeded during a given time period.
Isothermal	Of equal or constant temperature, with respect to either space or time; more commonly, temperature with height; a zero lapse rate.
Jet Stream (Upper Level)	A quasi-horizontal stream of winds 50 miles per hour or more concentrated within a narrow band embedded in the westerlies in the high troposphere.
Killing Frost	The frost sufficiently severe to damage the vegetation of an area. For the purpose of this report, when temperatures are 28°F or less.

Kinetic Energy	The energy which a body possesses as a consequence of its motion.
Lake Evaporation	Evaporation from a lake large enough and deep enough so that evaporation from most of its surface is unaffected by the temperature of the surrounding and underlying land.
Langley	Unit of energy per unit area commonly employed in radiation. One Langley is equal to one gram - calorie per square centimeter. The unit was named in honor of the American scientist, Samuel P. Langley (1834-1906) who made many contributions to the knowledge of solar radiation.
Lapse Rate	The decrease of an atmospheric variable (commonly, temperature) with height.
Latent Heat	The amount of heat absorbed (converted to Kinetic Energy) during the processes of change of liquid water to water vapor, ice to water vapor, or ice to liquid water; or the amount released during the reverse processes. Four such processes are condensation, fusion, sublimation and vaporization.
Leeward	The downwind side of an obstacle.
Mechanical Turbulence	The induced eddy structure of the atmosphere due to the roughness of the surface over which the air is passing.
Meridional	Longitudinal; northerly or southerly; opposed to zonal.
Mesoscale	Between 5 and 50 miles.
Micrometeorology (also, Microclimatology)	That portion of the science that deals with the observation and exploration of the smallest scale physical and dynamic occurrences within the atmosphere.
Moisture Deficit	The moisture deficit of a month is the potential evapotranspiration less the rainfall and stored soil water.
Molecular Friction	Whenever the surface of one molecule slides over that of another, each molecule exerts a frictional force on the other, parallel to the surfaces.
Orographic Lifting	The lifting of an air current caused by its passage up and over mountains.
Palmen's Model	A model describing the general meridional circulation of the earth's atmosphere.

Pan Evaporation	Evaporation of water from small pans exposed to the atmosphere. The standard Class A land pan is four feet in diameter and ten inches deep, raised six inches from the ground so that air can circulate around it. The depth of water in the pan is about 7 to 8" and should remain relatively constant.
Parameter	In general, any quantity that is not an independent variable. The term is often used in meteorology to describe almost any meteorological or climatological quantity or element.
Perturbation	Any departure introduced into an assumed steady state of a system.
Pluvial Indices	The amount of precipitation falling in one day, or other specified period, that is likely to be equalled or exceeded at a given place only once in a given return period (often, 100 years).
Polar Front	The semi-permanent, semi-continuous front separating air masses of tropical and polar origins.
Potential Energy	The energy which a body possesses as a consequence of its position in the field of gravity.
Potential Evaporation	A measure of the degree to which the weather or climate of a region is favorable to the process of evaporation.
Potential Evapotranspiration	Combined evaporation from the soil surface and transpiration from plants when the water supply in the ground is unlimited.
Pressure Gradient Force	The force due to differences in pressure within a fluid mass (e.g., air).
Radiational Fog	A major type of fog, produced over a land area where radiational cooling reduces the air temperature to or below its dew-point.
Radiational Inversion	An inversion at the surface due to radiational cooling.
Radiosonde	A balloon-borne instrument for the simultaneous measurement and transmission of meteorological data.
Rainfall Frequency	The number of times during a specific period of years that precipitation of a certain magnitude or greater, occurs or will occur at stations.

Pan Evaporation	Evaporation of water from small pans exposed to the atmosphere. The standard Class A land pan is four feet in diameter and ten inches deep, raised six inches from the ground so that air can circulate around it. The depth of water in the pan is about 7 to 8" and should remain relatively constant.
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Radiosonde	A balloon-borne instrument for the simultaneous measurement and transmission of meteorological data.
Rainfall Frequency	The number of times during a specific period of years that precipitation of a certain magnitude or greater, occurs or will occur at stations.

Rain Shadow	The region, on the lee side of a mountain or mountain range, where the precipitation is noticeably less than on the windward side.
Rainfall Duration	The length of a rain event.
Rainfall Intensity	The rate of rainfall, usually expressed in inches per hour.
Reflection	The process whereby a surface of discontinuity turns back a portion of the incident radiation into the medium through which the radiation approached.
Roughness	A measure of the irregularity of a surface over which a fluid (e.g., air) is flowing.
Saturation	The condition in which the partial pressure of a fluid, e.g., air, is equal to its maximum possible partial pressure under existing environmental conditions such that any increase in the amount will initiate a change to a more condensed state.
Saturation Vapor Pressure	The vapor pressure, at a given temperature, wherein the vapor of a substance is in equilbrium with a plane surface of that substance's pure liquid or solid phase.
Scattering	The process by which small particles suspended in the atmosphere diffuse a portion of the incoming solar radiation in all directions.
Sensible Heat	Same as enthalpy, which is the measure of heat imparted to a system during a thermodynamic process.
Snow Pack	The amount of annual accumulation of snow at higher elevations in the Western United States, usually expressed in terms of average water equivalent.
Solar Insolation	The total radiant energy from the sun incident on a unit area of a horizontal plane located at the surface of the earth.
Solar Radiation	The total electromagnetic radiation emitted by the sun.
Squall Line	Any non-frontal line or narrow band of active thunderstorms.
Standard Atmosphere	A hypothetical vertical distribution of atmopheric temperature, pressure and density, which by international agreement is taken to be representative of the global atmosphere.
Storm Track	The path followed by a center of low atmospheric pressure.

Stratosphere	The atmospheric layer above the tropopause, average altitude of base and top, 7 and 22 miles respectively; a very stable layer characterized by low moisture content and absence of clouds.
Stratus	A principal cloud type in the form of a gray layer with a rather uniform base.
Supercooled	The reduction of temperature of any liquid below the melting point of that substance's solid phase; that is, cooling beyond its nominal freezing point.
Supersaturation	In meteorology, the condition existing in a given portion of the atmosphere, when the relative humidity is greater than 100 percent.
Subsidence Inversion	A temperature inversion produced by the warming of a layer of descending air. The effect is the creation of a limited mixing volume below the stable layer.
Synoptic	In general, pertaining to or affording an overall view. In meteorology, it refers to the use of meterological data obtained simultaneously over a wide area for the purpose of presenting a comprehensive and nearly instantaneous picture of the state of the atmosphere.
Synoptic Scale	Weather patterns associated with high and low pressure systems in the lower troposphere, i.e., large scale.
Terrestrial Radiation	(also called earth radiation, eradiation) The total infrared radiation emitted from the earth's surface.
Thermal Buoyancy	Buoyancy attributable to a local increase in temperature.
Tropopause	The transition zone between the troposphere and stratosphere, usually characterized by an abrupt change of lapse rate.
Troposphere	That portion of the atmosphere from the earth's surface to the tropopause; that is, the lowest 6 to 12 miles of the atmosphere. The troposphere is characterized by decreasing temperature with height and by appreciable water vapor.
Turbulence	A state of fluid flow in which the instantaneous velocities exhibit irregular and apparently random fluctuations so that in practice only statistical properties can be recognized and subjected to analysis.
Ultraviolet (radiation)	Electromagnetic radiation of shorter wavelength than visible light but longer than x-rays.

Water Equivalent	The liquid water present within a sample of snow.
Wavelength	In general, the mean distance between maxima of a roughly periodic pattern (e.g., light).
Weather	The state of the atmosphere mainly with respect to its effects upon life and human activities. As distinguished from climate, weather consists of the short term (minutes to months) variations of the atmosphere. Popularly, weather is thought of in terms of temperature, humidity, precipitation, cloudiness, brightness, visibility and wind.
Wet Bulb Temperature	The temperature measured by a wet, muslim-covered bulb thermometer. The temperature an air parcel would have if cooled adiabatically to saturation at constant pressure by evaporation of water into it.
Wind Roses	Diagrams designed to show the distribution of wind speed and direction experienced at a given location over a considerable period. The most common form consists of a circle from which 8 or 16 lines emanate, one for each compass point. The length of the line is proportional to the frequency of wind from that direction; the frequency of calms is entered in the center.
Zonal	Latitudinal; easterly or westerly; opposed to meridional.

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